



NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

**OBJECT/SHAPE RECOGNITION TECHNOLOGY: AN
ASSESSMENT OF THE FEASIBILITY OF
IMPLEMENTATION AT DEFENSE LOGISTICS AGENCY
DISPOSITION SERVICES**

by

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December 2014

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DISPOSITION SERVICES**

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Submitted in partial fulfillment of the
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ABSTRACT

The Defense Logistics Agency Disposition Services (DLA DS) is facing substantial potential budget cuts, which will require the organization to increase efficiency and cut costs. DLA DS is assessing the feasibility to improve the item disposal process with an object/shape recognition technology as a means to increase efficiency. The technology may potentially reduce the time required to identify items in order to route for appropriate disposal. With the advancement of new technology and the availability of databases, it may now be possible to identify an object using recognition technology. Given the potential of these technologies to reduce identification time and errors, research to assess the viability of existing prototypes is justified. This applied project identified and assessed object/shape recognition technologies as a means to support efficiency while taking into account wider government policy and objectives in relation to technology adoption. This project evaluated the feasibility of implementation of these technologies that includes an analysis of DLA DS's items disposal process, a technology readiness assessment of the technology, and a cost-benefit analysis to assess the financial payoffs of an investment in the technology. The objective was to understand the items disposal process and assess object/shape recognition technology to address the problem that unlabeled items poses to DLA DS at Camp Pendleton, CA.

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LIST OF ACRONYMS AND ABBREVIATIONS

2D	2-Dimensional
3D	3-Dimensional
ADIRT	Automated Digital Recognition Technology
CBA	Cost-Benefit Analysis
CDD	Centralized Demil Division
CEA	Cost Effectiveness Analysis
COTS	Commercial-Off-the-Shelf
CPC	Controlled Property Center
DARPA	Defense Advanced Research Projects Agency
DEMIL	Demilitarized
CDD	Centralized Demil Division
DISA	Defense Information System Agency
DTID	Disposal Turn-in Document (DD Form 1348 1A)
DLA DS	Defense Logistics Agency Disposition Services
DLA	Defense Logistics Agency
DOD	Department of Defense
DODD	DOD Directive
DOE	Department of Energy
DODI	DOD Instruction
DSR	Disposition Services Representative
DSS	Distribution Standard System
ETID	Electronic Disposal Turn-In Document
FAR	Federal Acquisition Regulation
FEDLOG	Federal Logistics Data
FLIS	Federal Logistics
FTE	Full-Time Equivalent
FY	Fiscal Year
GAO	Government Accountability Office
GS	General Schedule
HAZMAT	Hazardous Material

IA	Information Assurance
JLOC	Joint Logistics Operations Center
LI	Line Item
LSN	Local Stock Number
MDAP	Major Defense Acquisition Programs
MICON	Military Construction
MUT	Mutilate
NRL	Naval Research Lab
NPV	Net Present Value
NSN	National Stock Number
NSB	Net Social Benefit
OCR	Optical Character Recognition
OMB	Office of Management and Budget
OSD	Office of Secretary of Defense
QDRR	Quadrennial Defense Review Report
PERT	Program Evaluation and Review Technique
PI	Profitability Index
PM	Program Manager
RCN	Receipt Control Number
RTD	Reutilization, Transfer, Donation
R&D	Research and Development
S&T	Science and Technology
SBIR	Small Business Innovation Research
SME	Subject Matter Expert
SOP	Standard Operating Procedure
TC	Technology Commercialization
TY	Then Year
TDY	Temporary Duty
TRA	Technology Readiness Assessment
TRL	Technology Readiness Level
TT	Technology Transition
TDTS	Technology Development & Transition Strategy Guidebook

UD	Ultimate Disposal
U.S.	United States
USAF	United States Air Force

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EXECUTIVE SUMMARY

The Defense Logistics Agency Disposition Services (DLA DS) is facing substantial potential budget cuts, which will require the organization to increase efficiency and cut costs. DLA DS conducted a Lean Six Sigma study in 2008 that led to streamlining the item disposal process and saving time equivalent to 40% of a full time employee. The Lean Six Sigma study concluded with a recommendation to identify and study the potential of technologies to support further efficiency gains (DLA DS, 2008).

This master's thesis was motivated by that recommendation. In the past decade, several companies have developed object/shape recognition systems to meet specific commercial requirements, with some success (Rajpurohit et al., 2013). The objective of this study was to identify and assess the viability of object recognition technologies for use by DLA DS.

This study is a mixed-method design including analysis of qualitative and quantitative data. Specifically, this study includes an analysis of DLA DS's items disposal process, a technology readiness assessment (TRA) of object/shape recognition technology, and a cost-benefit analysis (CBA) to assess the financial payoffs of an investment in the technology. The TRAs and CBA are consistent with the Circular A 94, DOD Directive 5000.2 Interim and DOD TRA guidance (OMB, 1992; DOD, 2013a; ASD[R&E], 2011). The study assessed a four-month period of data and utilized a market comparable approach to calculate the benefits and costs and return on investment. As a public service sector organization, DLA DS does not generate revenues. The study used the market comparable labor to estimate revenues.

This thesis' objective was to understand the items disposal process and assess object/shape recognition technology to address the problem that unlabeled items poses to DLA DS at Camp Pendleton, CA. However, the findings generated by the analysis of DLA DS's items disposal processing show three other areas of concern that contributed to days' worth of backlogged items. The data analysis suggests that the problem is not exactly the unlabeled items. Indeed, employees spend excess time conducting research on

items that are not labeled or are missing DD 1348 forms. However, unlabeled items are fewer than 1% of accepted items, and handling them does not solely 'create a backlog. The following three other areas of concern also contributed to days' worth of backlog. First, improperly filled DD 1348 provides for additional time spent conducting research in order to fill the DD 1348 form for further processing. Second, the receipt control numbers (RCNs) are not limited to the amount of items that can arrive in a pallet or tri-box. A RCN can have one or 50 items; therefore on average the facility accepts 425 items per day. The DLA DS at Camp Pendleton's capacity to process items is limited to 300 items with six-employee crew. Therefore, third, DLA DS at Camp Pendleton accepts more items than what it can process. The facility processes an average of 300 items per day; however, the excess items that were not processed contributed to have an average of 47 RCN equaling to about 2,259 items or 7.5 days' worth of backlogged items stored for later processing.

Furthermore, the thesis examined the alternative of addressing the unlabeled items issues with the use of new object/shape recognition technology. The DLA DS technological requirement includes item recognition and disposal information feedback, and the ability to take pictures to use on DLA email system to communicate and upload the picture to liquidations website. The TRA for three commercial-off-the-shelf technologies shows that they do not meet the maturity standard of TRL 7 required for DOD projects. However, Imaginestics' technology is the most viable and mature system, ranking up to TRL 5. Imaginestics' technology can be implemented in less considerable time and cost in reference to the other two companies.

The results of the CBA shows a total quantified net economic benefit occurring from the technology's contributions to be an estimated \$65,000 corresponding to an internal rate of return of 15% over a 10-year time span and profitability index (PI) 1.43, indicating that for every dollar invested \$1.43 in benefits is accrued with the payback period of almost seven years. The new technology will save money in labor costs for the unlabeled items; however, it only address less than 1% of items and not the 7.5 days' worth of backlogged items for the DLA DS facility located in Camp Pendleton. Therefore, the results from the queuing theory suggests that with nine employees the

DLA DS at Camp Pendleton will keep up with demand by processing all received items and will progressively reduce the 7.5 days' worth of backlogged items.

Areas of uncertainty remain for future study. This study was not able to capture time spent in every step of the item disposal process, or observe whether the backlog is a result of specific events such as retrograding units from deployments or the time of the year. The study did not assess the potential added value lost of scrapped items that might have been sold. For example if the technology increased the items sent for liquidation there would be an increase in revenues to DLA. Additionally, data was collected at one site, the Camp Pendleton DLA DS facility, such that the results may not be indicative of all DLA DS.

One of the main conclusions resulting from this thesis effort is that researching items is not the only area of concern with regard to process inefficiency. Rather, this thesis identified three other areas of concern suggested by the data analysis and observation. Therefore, further recommendations were provided to take care of the other three problems.

The TRA and CBA show that the implementation of object/shape recognition is viable, however the technology will address delays associated with the less than 1% of the backlogged items at Camp Pendleton. This study recommends DLA DS take steps to address additional identified concerns. This study recommends that DLA DS:

1. Making mandatory to fill the DD 1348 on DLA DS website, and
2. Limiting the amount of items on pallets to match the facility's processing capacity, and
3. Increasing the Camp Pendleton facility to nine employees, or
4. Adding a night shift such that the shift only process items without accepting or conducting mundane tasks, or
5. Once a month stop accepting items for disposal process for a full week in order to focus the effort to dispose the backlog items, or

6. Fill the gap with technology by implement full automation with optical sorting and data mining that included sensors, laser, object/shape recognition technology on conveyor belt system and data analytics to improve materiel's opportunity to be sold as commodity, or liquidations, and improve operational efficiency; which would be consistent with DLA Director's "Big Idea" and DLA DS's strategic technological goal to accomplish.

The technological innovation disrupts status quo by ensuring a plan of increased capacity for the long run and perhaps reduces some of the over \$60 million of labor cost that account for about 35% of DLA's budget.

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DEDICATIONS

I dedicate this work to my wife, Kellen; daughters, Briana and Brielley; my mother, Mrs. Myrna; my father, Mr. Juan; and my siblings and siblings-in-law for their love, moral support and encouragement. They were the motivation that fueled my long hours and late nights to complete this thesis.

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Foremost, I'm grateful to God for my family, my advisors and my strength, health and happiness to be enabled to complete this enormous task.

Doing an academic master's thesis the time allotted is not a small task for the novice—it's monumental! Dr. Geraldo Ferrer first accepted the challenge brought by the DLA into the Naval Postgraduate School, and then I accepted the topic to make it my project. I recognized right then and there that I, as a graduate student, could make a difference in the Department of Defense. Initially, as a researcher, my anxiety, fears and mixed feelings between the difficulty of developing ideas and my own curiosity generated many questions. Fortunately for me, they were put at ease when I had the pleasure to hear that Dr. Aten and Dr. Tick were interested in being my thesis advisors. That was a morale boosting moment for me and it gave me energy and confidence to conquer what no one else in my entire family has done to this day—pursue and complete a master's degree. However, my success is not solely on my own. There are many people who have supported me along the journey. Therefore, for that reason, I want genuinely want to express my humble gratitude. The list is not in order of precedence; however, each individual somehow has proportionately contributed to my success at the Naval Postgraduate School and for that wealth of knowledge I'm better off.

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Prof. Hudgens	Capt Foster
Mrs. McNally	Capt Lopes
Mr. Marroquin	Maj Denevan

GRACIAS, OBRIGADO, THANK YOU!

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I. INTRODUCTION

A. OVERVIEW

The budget cuts the Department of Defense (DOD) proposes to implement are creating a spending habit shift of the Defense Logistics Agency Disposition Services (DLA DS). The budget cuts will require the organization to increase efficiency and cut costs. DLA DS conducted a Lean Six Sigma study in 2008 that led to streamlining the item disposal process and saving time equivalent to 40% of a full time employee. The Lean Six Sigma study concluded with a recommendation to identify and study the potential of technologies to support further efficiency gains (DLA DS, 2008).

This master's thesis was motivated by that recommendation. In the past decade, several companies have developed object/shape recognition systems to meet specific commercial requirements, with some success (Rajpurohit et al., 2013). The objective of this study was to identify and assess the viability of object recognition technologies for use by DLA DS to increase efficiency and reduce costs. This chapter describes the problem facing DLA DS, which motivated this study; details the research questions that guided the study; provides a description of DLA DS technology requirements; and outlines the organization of this report.

B. THE PROBLEM STATEMENT

According to the Government Accountability Office (GAO, 2010), the Defense Logistic Agency (DLA) Dispositions Services (DS) identified \$1 billion worth of materiel for reutilization or disposal between fiscal years (FY) 2006 and 2008. However, identifying some materiel to allow reutilization or disposal has been difficult to efficiently accomplish. Time spent researching to identify material could be a key factor driving backlogs at DLA DS. Additionally, the research process may result in inefficiency and decrease goal attainment. In 2008, DLA DS initiated steps to improve the identification process by improving process flow, but further opportunities for improvement might be accomplished with technology (DLA DS, 2008).

In general, successful operations enhancement with technology saves money by providing faster service, reducing backlogs and reducing the cost of storing items. However, implementing technology has associated costs, including the cost of acquiring a technology that meets DLA requirements and also the cost associated with developing a technology for the specific needs of DLA DS. Development of immature technology increases the investment cost thereby increasing the payback period and reduces the willingness to invest. An effective evaluation of the technology's maturity is required to support informed decisions. While the DLA DS item disposal process flow has been improved, additional efficiency improvements are desired (DLA DS, 2014a). This applied research assesses the potential of object/shape recognition technology to improve the DLA DS's item disposal process by facilitating item identification. The aim is to evaluate the current state of object/shape recognition technology and assess the feasibility of implementing it at DLA DS.

C. RESEARCH QUESTIONS, SCOPE AND LIMITATIONS OF THE STUDY

This study addresses the questions that follow.

1. Is object/shape recognition technology a viable tool to improve DLA DS operations?
2. What are the technology needs for DLA DS?
3. What technologies are available and are they mature enough for implementation?
4. How much will the technology cost and will it generate any tangible savings?
5. What is the payback period?

1. Scope and Limitations of the Study

This study is a mixed-method design including analysis of qualitative and quantitative data. Specifically this study includes an analysis of DLA DS' items disposal process, a technology readiness assessment (TRA) of object/shape recognition technology, and a cost benefit analysis (CBA) to assess the financial payoffs of an investment in the technology. The TRAs and CBA are consistent with the Circular A-94,

DOD Directive 5000.2 Interim and DOD TRA guidance (OMB, 1992; DOD, 2013a; ASD[R&E], 2011). The study assessed a four-month period of data and utilized a market comparable approach to calculate the benefits and costs, and return on investment. As a public service sector organization, DLA DS does not generate revenues. The study used the market comparable labor to estimate revenues.

D. DLA DISPOSITION SERVICES TECHNOLOGY REQUIREMENTS

In recent years, significant progress has been made in the development of object/shape recognition technologies and their use in several real-time vision systems for detecting specific classes of objects within complex environments. This study assess the potential of several companies' technologies to meet the four technological needs that the DLA DS requires:

1. Identify government property via object/shape recognition or barcodes with national stock numbers (NSNs).
2. Provide disposition instructions.
3. Meet cyber security standards and information assurance requirement.
4. Take pictures to use on the DLA email system to communicate or upload to liquidation website.

E. ORGANIZATION OF STUDY

The remainder of this report is organized as follows. Chapter II reviews of relevant academic research including, technology commercialization, technology transition and technology readiness assessment research as well as literature from the DOD to provide a background and framework for this study. Chapter III describes the method used to investigate the research questions. Chapter IV describes the results of the analysis of Disposition Services at Camp Pendleton's items disposal process and the TRA of three companies' prototypes. Chapter V describes the CBA for object/shape recognition available technologies and discusses the results. Finally, chapter VI summarizes the key findings of the study, details recommendations for DLA DS supported by the findings, and makes recommendations for future study.

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II. LITERATURE REVIEW AND BACKGROUND

A. OVERVIEW

This chapter reviews academic literature and U.S. government policies in order to provide a description of the known understanding and developments in this area. The decision to adopt technology, particularly by government departments, is not an easy process and is not simply technology assessment in isolation. Many factors and processes must be taken into account. The objective of the chapter is to provide an overview of concepts and terminology related to government procurement of commercial items. This chapter reviews (1) the academic literature related to technology commercialization (TC) including challenges of developing and commercializing technology, (2) studies describing the generally accepted approach for cost-benefit analysis (CBA), and, (3) policies, procedures, and guidance of the United States' statute and law related to the acquisition of commercial-off-the-shelf (COTS) products, technology transition, and technology readiness assessment. This review provides a background and suggests a method to identify, evaluate and develop a solution to the DLA DS's property identification problem.

B. UNDERSTANDING THE TECHNOLOGY COMMERCIALIZATION PROCESS

New technologies have great potential but their commercialization has often proven challenging (Zahra & Nielsen, 2002). Technology Commercialization (TC) is of interest to academics and industry, and it has thus received a great deal of attention in the literature. Research has focused on identifying the processes to successfully manage commercialization; the development and launch of new products (Jolly, 1997, p. 20). TC seeks to identify the process through which innovative ideas are transformed into marketable products and to suggest means of overcoming challenges to commercialization.

1. What Is Technology Commercialization

TC is defined as the “process of acquiring ideas, augmenting them with complementary knowledge, developing and manufacturing saleable goods, and selling the goods in the market” (Zahra & Nielsen, 2002). Additionally, Jolly (1997) explained TC as “taking a design through development and then manufacture and market it” (p. 25). The literature on TC suggests that successful technology commercialization processes act as a technology accelerator (Markman, Siegel, & Wright, 2008). TC involves a series of incremental steps to move a technology along the technology-readiness scale. As explained by Jolly (1997), bringing new technologies to market requires five activities: imagining, incubating, demonstrating, promoting, and adopting. Mobilizing stakeholders, resources, and constituents, and delivering the product bridges the TC activities. The steps of the TC process should provide a means to assess whether the technology will work in a real application scenario as well as to evaluate the technology’s ease of use and determine how useful it will be and whether it is likely to be sustainable in the market (Jolly, 1997). If successful, TC will eventually introduce new technology to the marketplace and increase a firm’s competitive advantage (Zahra & Nielsen, 2002). However, TC has proven challenging (Jolly, 1997; Zahra & Nielsen, 2002).

2. Technology Commercialization Challenges

TC requires strategic decision-making in an uncertain environment and often outlaying upfront a large amount of capital. This creates challenges for stakeholders, which often may prove too great for to overcome. One of the fundamental reasons TC fails is due to having limited knowledge of what the customer wants or needs and the technology’s acceptance rate in the marketplace. According to Jolly (1997), failure is due to the demand never materializing or perception of poor product quality. Poor quality results in a lack of stakeholder interest and support, because the innovation doesn’t live up to the promised capacity (Jolly, 1997). Investors may perceive that the technology is too risky or unlikely to result in a worthwhile benefit, and a lack of funding may prevent research and development (R&D) and the commercialization process (Jolly, 1997). For example, in the DOD the process of budgeting for innovation has many constraints that

often make it difficult to continue to fund research and development (R&D) along the complete pipeline of development, consequently stalling projects for months (DOD, 2003). This hiatus is known as the “valley of death.” However, according to Jolly (Jolly, 1997), it is important to look at the big picture and figure out the links of failure or success in order to prevent further failure to continue to maximize success.

3. What Makes Technology Commercialization Work?

Assuming genuine innovation and strong market research, consistent communication across stakeholders and investor funding along with controlling other basic traits can fundamentally strengthen the TC process. According to Jolly (1997), “successful innovators tend to exchange more information and establish more efficient external communication links than their less successful counterparts” (p. 229). By taking this approach network uncertainty is naturally reduced through planning and increased communication among stakeholders. Good information is another important factor. In order to gather information during the TC process other scientists are considered the first customers of new technology (Jolly, 1997). They provide useful feedback to ensure that technological adjustments meet marketplace needs. Close management of the project during the early stages of product design refines the innovation process by monitoring and measuring resources used from R&D to marketing (Jolly, 1997). Additionally, incorporating market needs with the unique selling points to communicate how the new product is different and offers new functions increases acceptance (Jolly, 1997). Investor attraction requires a mix of the scope of the innovation in addition to the business and economical benefit rather than explaining the technological benefit alone (Kaarela, 2013). These actions support the successful commercialization of technology, thus boosting the confidence of stakeholders and potential investors (Figure 1).

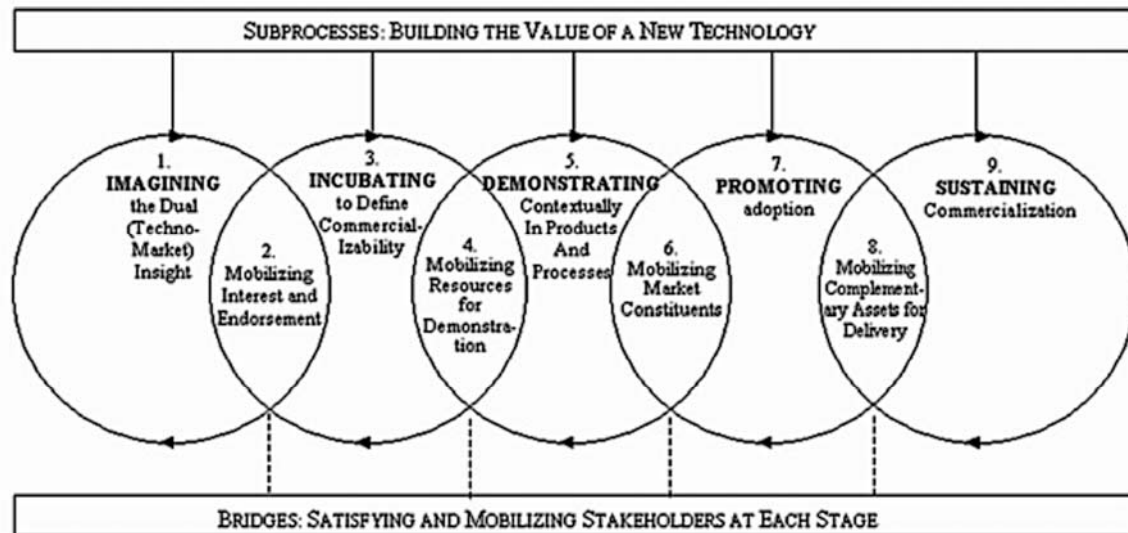


Figure 1. Technology Commercialization Process (from Jolly, 1997)

The TC process posed by Jolly (1997) illustrates a methodical approach to commercializing technology, as shown in Figure 1. According to Jolly (1997), stakeholders' interest, recognition, and moving resources are key principles of innovation. Stakeholder interest includes nine interconnected stages. Five subprocesses build value into the new technology by “imagining a techno-market insight; incubating the technology to define its commercializability; demonstrating it contextually in products and/or processes; promoting the latter’s adoption; and sustaining commercialization use” (Jolly, 1997, p. 46). Four additional stages bridge the subprocesses to satisfy and mobilize stakeholders and resources along the stages. The following five subprocesses are described:

1. **Imagining:** idea stage, linked together the incubating stage with “mobilizing interest and endorsement” (Jolly, 1997, p. 48).
2. **Incubating:** the “defining moment” where the resources are allocated (Jolly, 1997, p. 54); the demonstration stage is linked with the mobilizing resources stage.
3. **Demonstration:** product development links together the promoting stage with mobilizing market stage (Jolly, 1997, p. 60)

4. Promoting: “persuading people to adopt” (Jolly, 1997, p. 65) links together the sustaining stage with mobilizing assets for delivery.
5. Sustaining: “long presence in the market that generates fair shares on the long run” (Jolly, 1997, p. 69).

In summary, without recognition that all stages are equally important in the process—meaning that, without stakeholders’ interest, appropriate action and moving valuable resources in between every stage the commercialization—technology often fails.

This section discussed Jolly’s (1977) model as a tool in the TC. Communication and information gathering reduces uncertainty and gains the interest of the investors, who then provide project funding. Investors care about the bottom line and about showing the financial benefit that will have to be adopted in order to illustrate the financial cost and benefit of the project. Additionally, knowing enough of what the marketplace wants and needs is a function of successful TC. Finally, incorporating Jolly’s (1977) model provides guidance to facilitate the management of product development. TC is successful when challenges are overcome by including shareholders and investors in the communication process during every stage of commercialization.

C. COST-BENEFIT ANALYSIS

A cost-benefit analysis (CBA) is a tool that managers use to assess a project’s net benefit in monetary terms (Boardman et al., 2011). During the system’s engineering phase of the development process the DOD Directive (DODD) 5000.2 Interim, claims a CBA needs to be conducted, which resolves the “...supportability analysis, provides insight into supportability drivers and includes the impact of resources on readiness supported by engineering analyses required for product support” (DOD, 2013a, p. 215). In other words, all options must be considered and alternatives must be analyzed to showcase which one provides a greater impact and solution to meet user needs.

In the United States government, the guidance to conduct a CBA for any federal program is directed by the Circular A-94 *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (OMB, 1992). The Circular A-94 (OMB, 1992) provides instructional steps on how to plan and pursue a cost effectiveness analysis (CEA) in order

to depict the risk associated with implementing a project and lists the better options that out-weigh benefit over risk.

D. TECHNOLOGY TRANSITION

The DOD relies on having technologically innovative weapons systems in order to have an upper hand over any adversary. The technology transition (TT) process is a prominently accepted method by both private and public sectors to create effective technology systems. Congress, the DOD, and universities have established a number of “technology transition” programs (DOD, 2003; GAO, 2005). There are many variations of TT since technology transition has been practiced from the early 1800s (Geels, 2001). TT by itself is not the answer to successful product launch; however, it paves the way to smoothly and efficiently transition along the evolutionary acquisition system (DOD, 2003). The Defense Advanced Research Projects Agency (DARPA) and the U.S. Air Force (USAF) are examples of organizations that have fully embraced TT processes to innovate highly technological weapons.

1. What Is Technology Transition?

Technology transition occurs when an innovative concept is developed into a technological tool the R&D phase then transferred to the marketplace for use (Markman et al., 2008). The USAF (2010) defines *technology transition* in a more detailed “in-house” process that includes the following activities: “establishing a team, formulating the plan, developing information, coordinating and updating the information, obtaining commitment and approval at the proper stages, and executing transition.” In other words, the DARPA (2010) refers to technology transition as getting technology from research and into use.

2. What Are Technology Transition Challenges?

Technology transfers is a process that is prone to failure. One reason for TT’s failure is lack of oversight and supervision. According to the GAO (2005), “failure to track even the most basic information, such as the number of projects completed, could result in a lack of ability to manage the program properly and poor stewardship of

taxpayer money” (p. 25). This oversight contributes to instability of project progress to success and project failure. The GAO (2005) conducted a study on TT programs. The study centered on the management process, oversight and assessment practices for TT programs. The research highlights many of the ongoing barriers:

At this time, however, the transition programs have limited measures to gauge individual project success and program impact or return on investment in the long term. At best, they are collecting after action reports that describe the results of transition projects, and occasionally identify some cost savings, but not in a consistent manner. In addition, there are inconsistencies in how the reports are being prepared, reviewed, and used. The Quick Reaction Fund program manager, in fact, had trouble just getting projects to submit after action reports. (GAO, 2005, p. 22)

3. What Makes Technology Transition Work?

Consistent supervision can fundamentally impact a smooth TT process. The GAO (2005) research suggested the following:

Selecting promising projects for funding is not enough to ensure successful transition. Program managers must also actively oversee implementation to make sure that project goals are being met and the program is working as intended and to identify potential barriers to transition. They must also sustain commitment from acquirers. Moreover, the transition program as a whole must have good visibility over progress and be positioned to shift attention and resources to problems as they arise. (p. 18)

One of the best approach that supports TT success is to establish a database that facilitates the collection of pertinent information (GAO, 2005). The TT process posed by the USAF (2010) illustrates a methodical approach to technology transition as shown in Figure 2. The model highlights the linear process from accepting or approving a concept up to transitioning to a prototype.

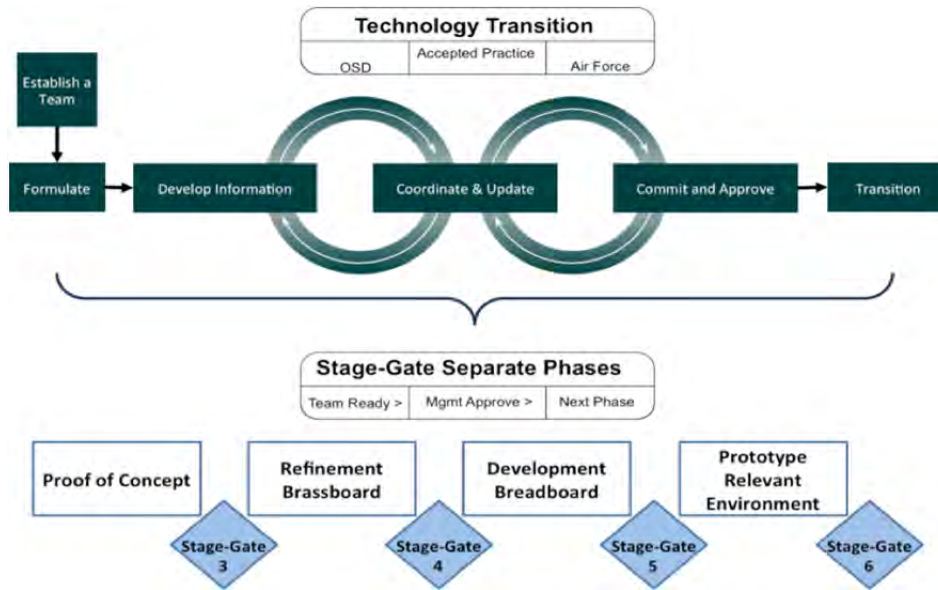


Figure 2. Technology Transition Process Flow Diagram (from USAF, 2010)

The USAF Technology Transition model in Figure 2 illustrates phases and stage-gates that are significant to the smooth process of TT and is applicable to this research. The figure illustrates a method to measure and approve technology before moving to the next stage. Although this model is depicted in a linear fashion the innovation process is often a circular model with many cycles of proof of concept and development before a prototype is ready. The TT process published by the USAF (2010) illustrates a managerial approach to approve a concept and transition technology from lab to a weapon system. The USAF adopted the stage-gate process due to its “industry-proven mechanism for effectively managing, directing, [and] otherwise controlling new product development efforts” (USAF, 2010, p. 8). The explanation of the activities and stage-gates is as follows:

1. Establish a team: Establish a team of stakeholders, managers and gatekeepers in order to make appropriate strategic decisions during all phases of technology transition.
2. Formulate: The team conducts an assessment using the Technology Readiness Level (TRL) tool to establish a baseline of the technology’s maturity and formulates a strategy to mature it for a final product. Section E provides TRL definitions and details.

3. Develop information: The team gathers milestone maturity information for approval to move to the next level.
4. Coordinate and update: The team communicates across stakeholders and controls the approval process to move to the next gate.
5. Commit and approve: The team evaluates and agrees to one of the decision criteria, “go/hold/no-go,” to transition the technology.
6. Transition: The likelihood of successful technology transitions to produce a product.

The six gate-stage phases are “intended to provide a disciplined approach to executing a technology maturation effort, including consideration of all technical and acquisition factors associated with a successful transition. Ultimately, the use of the stage-gate process will facilitate laboratory, engineering, and programmatic reviews” (USAF, 2010, p. 9). During the *Proof of Concept* stage, the team approves the concept to make a prototype. In the *Refinement* stage, the prototype is refined for *Development* in stage-gate 4. Subsequently, in stage-gate 5, the developed prototype is tested in a *Relevant Environment* and approved to transition to stage-gate 6. The USAF (2010) claimed that this method formalizes the process and keeps their “eye on the prize.” In general, this method is a building strategy, beginning with R&D to mature the technology and progress from Technology Readiness Level (TRL) 3 through TRL 6, then the project transitions to an acquisition program for further maturation (USAF, 2010, p. 8).

The USAF’s Technology Transition model illustrates a revolutionary process to effectively and efficiently implement a concept into a system. This section described the managerial process to effectively transition technologies in the DOD. The next section explains how one moves from processes to TRLs.

E. TECHNOLOGY READINESS LEVEL

The DOD spends billions of dollars developing advanced major defense programs. Technology Readiness Assessment (TRA) helps with the evaluation of any given’s technology maturity in order to reduce risk and cost of implementation and utilization (Department of Energy [DOE], 2012). The TRA is a widely accepted model used in the U.S. government’s acquisition process. TRL is just one of two approaches for

assessing technology maturity. The GAO added an additional element to the evaluation process when assessing technology maturity. In addition to the TRA, the GAO (2003) presented a system's profile element during the maturity assessment. The profile includes, a general description, pictures, key elements of the system, and a schedule that covers milestone and completion dates. Acquisitions of systems are not limited only to the DOD: in 2012, the Department of Energy (DOE) had over 400 active projects such that the DOE relied on the TRA methodology to review and assess these advance energy systems. Regardless of the agency or departments' assessments requirement, the TRA and system profile both evaluate the technology in order to timely recognize and rectify gaps, mitigate risk, control timelines, and reduce or control cost.

1. What Is Technology Readiness Assessment, and How Is it Measured?

The DOD (2011) defined TRA as “a systematic, metric-based process that assesses the maturity of, and the risk associated with, critical technologies to be used in Major Defense Acquisition Programs (MDAPs)” (p. 1–1). In order to make the transition from the laboratory to product, the TRA can serve as a helpful knowledge-based standard and shorthand used to evaluate the technology's maturity (ASD[R&E], 2011). The evaluation provides a numeric value known as Technology Readiness Level (TRL) that measures technology from mature or near mature.

TRL is a disciplined ranking system of technology's maturity rated between TRL 1 and 9. The TRL analytical tool is well defined and is the best practice approach in evaluating the technology's maturity. The milestone levels are as follow: TRL 1 contains conceptual documented paper studies of technology's basic properties; TRL 2 is when the concept becomes a practical application to invent the system; TRL 3 is when the analytical and experimental laboratory scale models are observed; TRL 4 undertakes the component for validation in the laboratory; TRL 5 contains applied research laboratory scale experimentation; TRL 6 is where a model or prototype is demonstrated in a relevant environment; however, this is not the only consideration because the evaluation is supplemented with expert professional judgment; subsequently, TRL 7, is a prototype that can be presented and tested in actual relevant environment; TRL 8 is where the

actual system is tested to for demonstration in a plant environment, to consequently the systems is built in TRL 9, which is ready for use in operational mission conditions (ASD[R&E], 2011). (All the TRLs are more fully explained below in Table 1.) The DOD's (2011) benchmark is whether technological evolution gives greater capabilities; however, to reap the benefit and not waste money during the R&D process, evaluating and assessing the technology's maturity would increase efficiency of the investment (Sohn & Moon, 2003).

Moreover, the GAO (2003) assessed systems in two components: (1) a system's profile and (2) a product knowledge assessment:

1. System profile: the first component is the system profile detailing the general description of the product with pictures and key elements such as schedule timeline and cost (GAO, 2003).
2. Product knowledge assessment: the second component is the product knowledge assessment where the technology is assessed and given a TRL ranking (GAO, 2003).

Knowing the levels provides an unbiased approach when evaluating technology maturity. According to the GAO (2003; 2009a) and DOE (2012), the benchmark and best practice to claim technology maturity is TRL 7. Significantly, TLR 7 enables the technology prototype to be evaluated in a realistic operational environment resulting in low risk reduction to enter production and implementation. The GAO (2003; 2009a) stated that a system in TRL 6 is referred as approaching or nearing maturity and is 50% of the desire knowledge level. In a relevant environment, technology is evaluated in a high fidelity laboratory simulated operational environment, whereas an operational environment is where the system is intended to operate (ASD[R&E], 2011). As depicted in Figure 3, the researcher drew from the DOE's (2012) framework for the model flow of technology assessment progress in order to have a visual guide. Furthermore, an illustration is provided in Table 1 that contains details of definition, description and supporting information of all the technology readiness levels in the TRL model.

Technology Readiness Level Model

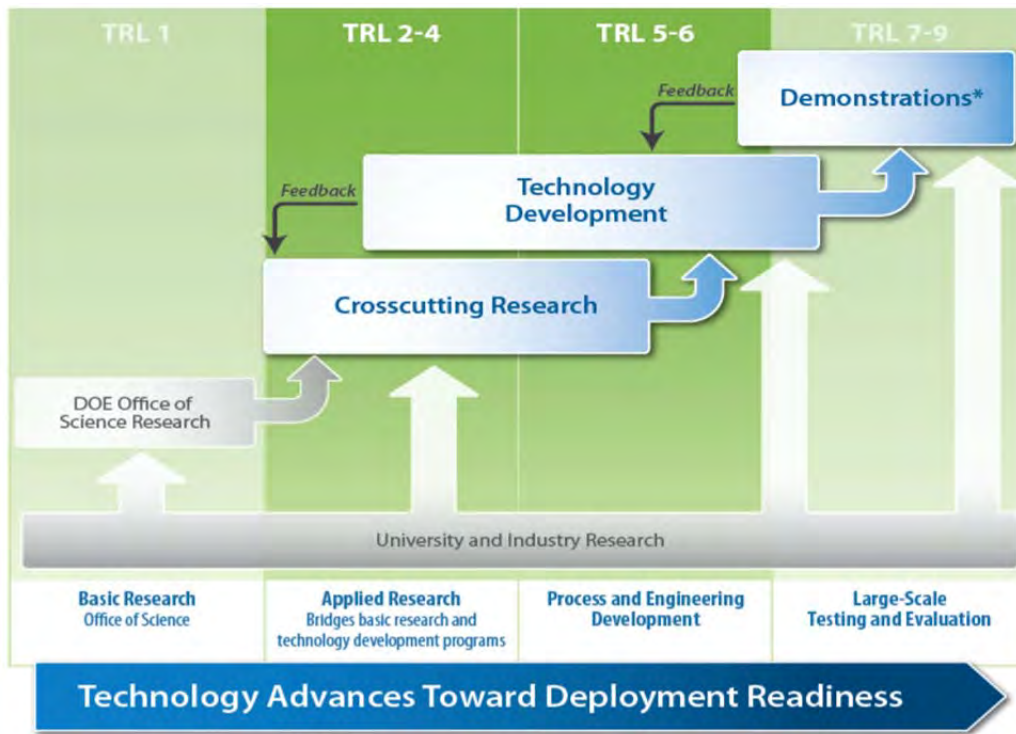


Figure 3. Progress Flow of Technology Readiness Levels (from DOE, 2012)

The DOE's (2012) TRL model was adapted to develop the guiding framework for this study as illustrated in Figure 3. The process begins from research department such as a university or a research industry. Universities and industry research departments continuously provide input throughout the cycle but the model does not have to include this collaborative knowledge exchange format and is equally relevant to in-house development programs. Levels of readiness increase as concepts are moved to laboratory for research. Once a prototype is developed, the prototype is tested in a mission environment where the technology is evaluated. Full production occurs when TRL 9 is accomplished. At each stage/level feedback is imperative provided by the project's manager and the project's authority approving level in order to control the process and meet requirements.

Adopted from the *USAF Technology Development and Transition Strategy (TDTS) Guidebook* (USAF, 2010), Table 1 provides a visual chart of definitions for the TRL from 1–9. Row 1 displays the numeric attributes for the technology readiness level,

row 2 displays the basic definition and row 3 displays a detailed description for each level. But, most importantly, a technology is considered fully mature at TRL 7, when the prototype is tested in the relevant operational environment and this level is the DOD's minimum maturity level for consideration to satisfy requirements is TRL 6 (ASD[R&E], 2011).

Table 1. Technology Readiness Level Definitions (from USAF, 2010)

TRL	Definition	Description
1	Basic Principles Observed and Reported	Lowest level of technology readiness. Scientific research begins translation to applied research and development. Examples might include paper studies of a technology's basic properties.
2	Technology Concept and/or Application Formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples remain limited to paper studies.
3	Analytical and Experimental Critical Function and/or Characteristic Proof of Concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4	Component and/or Breadboard Validated in Laboratory Environment	Basic technological components are integrated to establish the feasibility that the pieces will work together. This is relatively low fidelity compared to the eventual system. Examples include integration of ad hoc hardware in a laboratory.
5	Component and/or Breadboard Validated in Relevant Environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include high-fidelity laboratory integration of components.
TRL	Definition	Description

6	System/Subsystem Model or Prototype Demonstrated in Relevant Environment	Representative model or prototype system well beyond the breadboard tested for TRL 5 undergoes test in a relevant environment. Represents a major step in a technology's demonstrated readiness. Examples include prototype testing in a high-fidelity laboratory environment or simulated operational environment.
7	System Prototype Demonstrated in Operational Environment	Prototype near or at planned operational system. Represents a major advance from TRL 6 and requires demonstration of an actual system prototype in an operational environment (e.g., in an aircraft or other vehicle or in space). Examples include prototype testing in a test bed aircraft.
8	Actual System Completed and Flight-Qualified Through Test and Demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine whether it meets design specifications.
9	Actual System Flight-Proven Through Successful Mission Operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this ends final debugging aspects of true system development. Examples include system usage under operational mission conditions.

In summary, this section provided a general discussion of the label system when ranking technology's maturity ranging between TRLs 1–9. Since the creation of the technology government, companies have used it increase competitiveness by having policies in place to achieve successful products and systems development. The next section discusses what the U.S. government and the DOD have done to guide innovation.

F. FEDERAL ACQUISITION STATUE AND LAW, AND DOD DIRECTIVE AND INSTRUCTION

Over the past three decades, the U.S. government has developed an increased interest in regulating all acquisitions of supplies and services by all the federal executive

agencies. In addition, the federal government issued laws to regulate the technology transfer from the commercial sector to use in the DOD. This section reviews the Federal Acquisition Regulation (FAR), major DOD policies and directives related to regulating technology transition, and the risks and benefits associated with the acquisitions of commercial off-the-shelf items (COTS) to support the mission.

1. Federal Acquisition Regulation

U.S. government's acquisition regulation became effective in April 1984 (FAR, 2004). The government's preference for procurement of commercial items is contained in the following statutes: 41 U.S.C. § 1906, § 1907, and § 3307 and 10 U.S.C. § 2375–2377 (FAR, 2004, p. 12.1–1). In addition, the acquisition approach for the technology maturation effort of systems is covered in: 10 U.S.C. § 2304, 10 U.S.C. § 2305, and 10 U.S.C. § 2306) (USAF, 2010, p25). The FAR (2004) is the strategic policy that directs agencies to “conduct market research to determine whether commercial items or non-developmental items are available that could meet the agency's requirements” (p. 12.1–1). The foundation to link the private sector's technological leadership with the DOD's developmental technological needs was emphasized in the 2001 Quadrennial Defense Review Report in order to provide the best piece support in the field (OSD, 2001). The FAR is the documented source that guides DOD towards integration of the commercial sector's capabilities to meet the U.S. military's technological needs, while the DOD directives and instructions provide the template to managing and acquiring COTS.

2. Department of Defense Directives

The DOD annually spends billions of taxpayer dollars developing and procuring systems. In order to ensure positive returns on investment, the DOD has established policies and directives to adopt the “best practice” in developing and procuring equipment and weapons quickly and cheaply (GAO, 2003) The DOD's best practice to manage the procurement of systems and technology transition procedures are underlined by the mandatory principles, DOD Directive (DODD) 5000.1, *The Defense Acquisition System*; and DOD Instruction (DODI) 5000.2 Interim, *The Operation of the Defense Acquisition Systems*.

a. DOD Directive 5000.1

Congress and DOD leaders recognize the contribution and benefit associated with the procurement of COTS products, services, and technology for greater effectiveness and efficiency. One of the primary objectives of DODD 5000.1 (DOD, 2007) is to promote innovation, flexibility and management. The policy's objective is "to acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price" (DOD, 2007, p. 3). The DODD 5000.1 (DOD, 2007) stated the following with regard to market research and procurement:

DOD Component(s) shall consider multiple concepts and analyze possible alternative ways to satisfy the user need. ...The DOD Components shall seek the most cost-effective solution over the system's life cycle. They shall conduct market research and analysis to determine the availability, suitability, operational supportability, interoperability, safety, and ease of integration of the considered and selected procurement solutions. The DOD Components shall work with users to define capability needs that facilitate the following, listed in descending order of preference:

The procurement or modification of commercially available products, services, and technologies, from domestic or international sources, or the development of dual-use technologies. (p. 8)

DODD 5000.1, *The Defense Acquisition System*, describes the management principles for DOD's knowledge-based acquisition programs and these principles are a mandated directive that stresses best practice approach during the development of systems process (GAO, 2003).

b. DOD Instruction 5000.2 Interim

An important task during the conduct of technology transition is the enhancement or rapid development of military systems. The primary element involved during the system engineering processes is to "mature, prototype, and demonstrate the suite of selected system elements and complete the preliminary design of the full system for low-risk entry to Engineering and Manufacturing Development" (DOD, 2013a, p. 232). To promote the technology transition and maturation the DOD Instruction 5000.2 Interim (DOD, 2013a) provides the following amplifying guidance:

...an investment decision to pursue specific product or design concepts, and to commit the resources required to mature technology and/or reduce any risks that must be mitigated prior to decisions committing the resources needed for development leading to production and fielding. (p. 7)

Furthermore, the directive provides detailed guidance with regard to acquiring COTS from the commercial sector such as small business, academia and government laboratories:

Promising technologies shall be identified from all sources domestic and foreign, including government laboratories and centers, academia, and the commercial sector. In addition, PMs [program managers] shall consider the use of technologies developed under the Small Business Innovation Research (SBIR) program, and give favorable consideration to successful SBIR technologies. The risk of introducing these technologies into the acquisition process shall be reduced; coordination, cooperation, and mutual understanding of technology issues shall be promoted. The conduct of Science and Technology (S&T) activities shall not preclude, and where practicable, shall facilitate future competition. (DOD, 2013a, p. 14)

DOD Instruction 5000.2 Interim, *The Operation of the Defense Acquisition System*, outlines a framework for managing acquisition programs. According to the GAO (2013), about 40% of all 2012 systems were 25% or more over budget with over two years of scheduled delays. To provide control and improvement of these two elements—cost and schedule—the updated DODD is expected to provide flexibility to procure COTS. The directive indicates, with great emphasis, that there is a relationship between requirements, acquisitions, and budgeting processes such that all three components work together to identify and resolve issues early as possible (DOD, 2013a). Moreover, the directive suggests that actions required for cost reduction, especially for information technology systems, is achieved during the compliance to “redesign the processes that the system supports to reduce costs, improve effectiveness and maximize the use of commercial off-the-shelf technology” (DOD, 2013a, p. 71).

c. Commercial-Off-the-Shelf Regulations

The FAR and DOD regulation encourages the acquisitions of commercial-off-the-shelf items. According to Allen (2008), the use of COTS involves accepting some

benefits and risks. However, according to the DOD Instruction 5000.2, the use of COTS is worth investigating:

The use of commercial-off-the-shelf (COTS) items, including Non-Developmental Items, can provide significant opportunities for efficiencies during system development but also can introduce certain issues that should be considered and mitigated if the program is to realize the expected benefits. (DOD, 2013a, p. 175)

According to the directive (DOD, 2013a) the benefits associated with COTS include the following:

1. System development time reduction
2. A faster integration of technology
3. Lower system life-cycle cost is lower due to leveraging available commercial technology

Nevertheless, there are risks associated with using COTS. Allen (2008) put it best when specifically referring to the procuring of software COTS: stating “the risk is that selecting the wrong COTS software component might be more expensive than fixing problems in custom-built software” (p. 80). Furthermore, according to the directive (DOD, 2013a), there are concerns associated with COTS. The following, relevant to this study, are five major elements to name just a few from a wide-ranging list:

1. “If integration requires a ‘modified COTS product,’ meaning that a COTS product may not be designed for many military environments (which, by definition, is not a COTS product under section 403 of title 41, United States Code, but is allowed under section 431 of title 41, United States Code), then the program may lose the ability to use the vendor’s subsequent product upgrades or to find a suitable replacement for the product from other commercial sources” (DOD, 2013a, p. 175).
2. “The vendors can embed proprietary functions into COTS, limiting supply sources” (DOD, 2013a, p. 175).
3. Supply chain risk management of COTS items is limited by the vendor, who is under no obligation to the purchaser to provide such information (DOD, 2013a, p. 175).
4. Difficulty in finding suitable replacements and/or alternate items if the COTS vendor stops manufacturing the product or changes the

configuration drastically, requiring the need to maintain different configurations of a single product (DOD, 2013a, p. 175).

5. The graphical user interface (GUI) design may not completely support user tasks, which can cause inefficient workarounds and improper use of the system by the user (DOD, 2013a, p. 175).

According to Allen (2008), the best approach to reducing risk and concern when utilizing COTS is to adhere to DOD policies, maintain flexibility when incorporating COTS into the project, avoid restrictive statements of work and avoid very specific details that the technology ends up being unique to government (p. 80). Regardless of the extent to which the agency plans to use COTS, rigorous testing, evaluation, and acceptance of some risk must be undertaken in order to integrate the technology, streamline process, and reduce cost.

This section introduced statutory preferences, directives and regulations that authorize the DOD to consider procurement of technological capabilities from the commercial sector. The core mission is for the DOD to consider commercial technological capabilities during the decision processes to possibly reduce development time, cost and leverage technology to sustain a competitive edge. Today, these laws and guidance dominate the DOD's nature of acquiring major weapon systems in order to reduce cost (Markman et al., 2008)

G. COTS OBJECT/SHAPE RECOGNITION TECHNOLOGY

In day-to-day routine, humans rely heavily on their vision to identify the world as they see it. This is a natural and effortless human process; however, to develop a machine to accomplish the process is a complex and ambitious project. Currently, a group of scientists has developed a prototype of object/shape recognition and images processing prototype that can identify leafs (Rajpurohit, Bhat, Devurkar, Patil, & Sirbi, 2013). Scientists are rapidly improving and advancing the technology and some major companies have adopted early versions. This section describes object/shape recognition technology and its utility in the private and government sector.

1. What Is Object/shape Recognition Technology

Object/shape recognition technology is a tool that identifies items using a vision-capturing device and recognizes an object as a member of a category containing other similar objects (Frome, 1996). The application of the object/shape recognition technique by an image-capturing tool is an approach to identify items for the purpose of classification (Rajpurohit et al., 2013). There are different approaches and methods, but all have elements in common: algorithm program, image capture apparatus and database to compare the image of interest to provide feedback.

Object/shape recognition technology uses a program to index a database in order to translate received data, and then compares it to data in the database to provide feedback. In general, the infrastructure consists of several components that include an image capture apparatus for shape searching. The image signature is turned into digital data in order to compare potential leads in the database. The database server contains all information for matching as well as adding and classifying newly captured data. Another added feature would be that the program learns while comparing, so its information is readily available for future use. Finally, the tool returns feedback through wireless or cable connection. Conceptually, the tool identifies the object and its shape; then it translates that image into algorithm to digitally search a like category from the database; and finally, it provides feedback with the matching item (David & DeMenthon, 2006).

2. Object/shape Recognition Technology's Utility in Private and Government Sectors

Many major companies in the private sector and U.S. government are using some form of object/shape recognition technology to differentiate and carve out a competitive edge, for instance, Amazon, with its newly released Fire Phone that has an application called Firefly. The Firefly application captures images of items for the purpose searching it on Amazon.com for purchase (Matz, 2014). Similarly, the DOD has an invested interest in the technology's benefit such that the Naval Research Lab (NRL) has created a prototype.

Computer vision, image processing detection and recognition, and machine learning have increasingly become of great interest to the DOD for general intelligence, target recognition, and data analysis. Currently, the NRL claims to have developed a “rapid recognition and location of surface shapes in range images” (Manak, 2014). According to the NRL, the technology can differentiate parts in a clutter environment with accurate recognition.

Accordingly, the object/shape recognition technology from Amazon and NRL are two examples from the private and government sector. The U.S. government and private sectors’ interest in recognition technology is for enhancement in their internal processes’ efficiency or to carve a competitive edge. Their interest in the benefits attained by the technology ensures that gaps are filled to evolve the object/shape recognition technology. Additionally, with the advancement of new commercial technology and resourceful databases, there are opportunities to mature object/shape recognition technology.

H. CHAPTER SUMMARY

With technology rapidly evolving and the increasing need to sustain a competitive edge, the federal government must keep abreast of technological changes. It is beneficial to ensure that both the government and the industrial sector maintain open lines of communication in order to collaborate and meet efficiency requirements. This chapter reviewed the elements that may impact the decision-making with regard to improving the current property processing systems. Specifically, this chapter reviewed the generally accepted processes for technology commercialization, CBA, U.S. government’s assessment of technology transition, technology readiness and, statutory policies, directives and regulations.

The take away is that TC differentiates the technology to target the appropriate consumers or users. Parameters or measuring techniques are in place to reduce risk, control cost, and creates timeline. The evolutionary process begins from concept, continues onto the lab for development, and ends with an operational product for warfighters to use in the actual field environment. The TT process is one of the main frameworks that effectively incorporates the system or product. TRLs establish

parameters to evaluate technology's maturity. In general, a technology is claimed to be mature for production, or roll-out in the case of software, when it accomplishes TRL 7. However, DOD considers TRL 6 the benchmark to proceed with system development. The statutory codes and DOD guidance provide direct orders to follow with regard to considering the commercial industry's technological advancement and adapting it to the government's needs. All the theories, guidance, and concepts reviewed in this chapter are important elements to refer to and which guided this study in answering the research questions. The focus of the subsequent chapter is to describe the research approach and methodology that lays the foundation of the analyses for conducting this study.

III. METHODOLOGY

A. INTRODUCTION

This chapter presents in detail the analysis steps taken to address this project's objectives, to conduct an analysis of the DLA DS property process and evaluate the technology readiness level (TRL) in order to assess the feasibility to implementing a property identification technology, and to conduct a cost-benefit analysis (CBA). This applied research study utilizes mixed methods. Mixed methods are used to conduct three analyses. First, the study uses a process analysis to understand DLA DS's property disposal operational process. Second, it also uses a technology readiness assessment method to assess the viability of implementing object/shape recognition technology by the DLA DS. Finally, the study utilizes a CBA method in order to assess DLA DS' property identification operational cost and benefit values provided with technology and without technology for the purpose of financial analysis. Each method and its respective data sources for each are described in the following sections. The approach's purpose is to set a baseline to conduct the qualitative and quantitative analysis.

The main objective of an applied research is to explore a practical situation's solution to a problem (Booth, Colomb, & Williams, 2008). The applied research has two major components. One component is *knowing* how to account for factors in identifying the problem; the second is *doing*—rectifying the problem with a solution (Booth et al., 2008). This thesis' focus of effort is to find a solution to the DLA DS property identification process determine feasibility in order to apply technology to the process therefore; for this reason the researcher designed this applied research methodology.

B. PROPERTY DISPOSAL PROCESS ANALYSIS METHODOLOGY STEPS


This section underlines the steps by which the researcher analyzed the property identification process. Currently, DLA DS disposes of items using a seven-step process. Each step was analyzed to understand the process flow and to identify inefficiencies and problems.

1. Data

The researcher visited DLA DS at Camp Pendleton to observe procedures for processing property. The researcher visited the site and observed the process for three hours and asked clarifying questions to document the process. During the visit the researcher took detailed notes and pictures and identified relevant documents such as standard operating procedures, training manuals and reports from the Government Accountability Office (GAO). These reports were then collected to provide data for the study.

a. Data from Previous Studies

In 2008, DLA DS captured investigated DS property process. During that study one of DLA DS facilities was observed processing property (see Figure 4; DLA DS, 2008). The result from the 2008 study is particularly important because it provides a sample number and the time it took to accomplish each task. Steps of focus for this thesis are 5, 6, and 7. Step 5 contains the sample size of items 25 items' local stock numbers (LSNs). Steps 6 and 7 contain the time it took to match and research LSN's. Although plenty of analysis can be generated from the "time study" data, the interest of this thesis is to calculate the average time to research each LSN item that needed further verification; therefore, the following represents the generic average formula:



Time Study

Process owner	Step	Time Study	Process	Notes
CPC	1		CPC notifies contractor Batchlots ready for verification	Time study performed for batchlot of 80 line items
GL	2	3 min	Contractor locates F/L	
GL	3	5 min	Batchlot is pulled from location to verification line	
GL	4	10 min	1348 documents in packing envelope are sorted by NIIN	
GL	5	4:48	Property is pulled from tri-wall/carton, verification of NSN/QTY/DTID/Demil against 1348	Property is displayed/sorted by NSN or LSN test Results: NSN-55 LSN-25
GL	6	30 min	property is matched with 1348 documents that were previously sortedc by NIIN	
GL	7	1:01	Research LSN items utilizing Webflis/Fedlog	
GL	8	30 min	NSN and DTID of items are scanned with RF	While scanning message is displayed to alert user of any potential FSCAP, F14, Demil B & Q. Research is performed simultaneously
GL	9	15 min	LSN items: DTID is scanned with RF and LSN is input manually	
GL	10	10 min	Spreadsheet of batchlot items is generated Contractor annotates notes on spreadsheet to identify F14, FSCAP, Demil B & Q	
GL	11		Spreadsheet is sent by email to CPC for verification	
CPC	12		CPC receives spreadsheet	
CPC	13	4 min	CPC prints and reviews spreadsheet for errors	
CPC/GL	14	31 min	CPC and contractor perform joint verification of line items and 1348 compared with spreadsheet	if errors are identified spreadsheet is sent back to contractor to correct
CPC	15	10 sec	NSN's from spreadsheet are transferred into "Tool" items flagged are further researched along with acquisition dollar to determine if items are over/under	If corrections are needed spreadsheet is sent back to contractor to correct prior to completing joint inspection
CPC	16		"Tool" spreadsheet is sent by email to contractor	
GL	17	12 min	IDR is prepared and sent by email to verifier	
CPC	18		CPC receives IDR and prints copy	
CPC/GL	19	4 min	IDR is signed by verifier and contractor	
CPC	20		Signed IDR is provided to CPC technician	
		Total 8:55		

Figure 4. Process Flow Time Study per Step (from DLA DS, 2008)

Note: Average researched time to per LSN = Total time to research LSN's / total number of LSN's researched

Depicted in Figure 4 is the average time employees take during each step for one cycle of property processing. A description of the columns 1 through 5 is as follows: responsible employee completing the task, step in the process, time to accomplish task in the respective step, description of task process undertaken by employee, and notes identified during the study, respectively. The carrying time weight per step in Steps 5, 6 and 7 is notable. Step 5 takes the longest to accomplish while Step 6 carries the third-most time in the cycle.

The most recent study was conducted in 2013. The study resulted in streamlining the property process by up 35% (see Figure 5; DLA DS, 2013). This information is particularly relevant to this thesis because it provides the standard by which employees'

performance is measured. The measurement relevant for this thesis is the final average resulting in 7.5 receipts per person per hour. These results were utilized to calculate hours spent processing items in the item processing analysis.

Receipt Process Data (Property Entering CDD gate to Property Stowed)					
(1) Day	(2) Date	(3) # Incoming Trucks & Badged Trucks	(4) Net # of Receiving FTE / TDY	(5) Items "Received"	(6) = 5 / 4
Mon	19-Aug-2013	2	10	321	32.1
Mon	26-Aug-2013	12	9	329	36.6
Tue	20-Aug-2013	11	9	138	15.3
Tue	27-Aug-2013	16	10	564	56.4
Wed	21-Aug-2013	6	10	526	52.6
Wed	28-Aug-2013	13	11	636	57.8
Thu	22-Aug-2013	18	9	811	90.1
Thu	29-Aug-2013				#DIV/0!
Fri	23-Aug-2013	5	7	589	84.1
Fri	30-Aug-2013				#DIV/0!
Totals:		83	75	3914	52.2
∴ Average Receipts per Person per Hour:					7.5

Figure 5. Study to Measure per Person Hours per Property Received for Process (from DLA DS, 2013)

Figure 5 illustrates in a four-week period the average receipts of each person per hour, 7.5. Column 1 indicates the day of the week while column 2 is the date; column 3 illustrates the number of trucks for the day; column 4 records the full-time equivalent (FTE) and/or people doing the work who are on temporary duty assignment (TDY); column 5 shows how many items were received, and column 6 is a ratio of items received divided by FTE received (col 5/col4; DLA DS, 2013).

b. New Data, Collected from DLA DS at Camp Pendleton

The author of this thesis travelled to Camp Pendleton, CA, and collected two types of data sets that cover four months of property processing information. One data set contains data on the total amount of unidentified items that were researched during the week. The second data set contains daily, weekly, monthly and annually data on identified (input) and processed (output) items at Camp Pendleton starting with date 1

July 2014 until date 21 October 2014. The summaries of the two data sets are presented in Figures 6 and 7, respectively. The main take away from Figure 6 is the total number of researched LSNs that were reported on July 14 used to calculate a historical quantitative relation between items researched and items received. This calculation of the ratio number is presented in Figure 7. The generic ratio formula is as follows:

Researched LSN List

PARENT DTID:	LSN	Approved As Demil Code	COMMENTS NSN Found
CHILD DTID NUMBER:			
R5709440380046	811500CASE	A	6760-01-519-0711
N6312640525C5J	N6312640525C5J	D	
N6312640525N5J	5840DSRADAREQ	D	
N6312640101F5J	N6312640101F5J	A	
M93338-4195-Q303T	6130-DSUPS00033	Q	
EZ128041272416	6636DSENVCHMBR	A	
N6312640525H5J	6605DSNAVIGAT	D	
N6312640525G5J	5840DSRADAREQ	D	
N6312640303B5J	5840DSRADAREQ	D	
W900DB41710001	518001C047509	A	
FX231533390021	1560DSPANEL00	D	
M3380042020018	5180DSTOOLKIT	A	
Disp. Svcs Site:	7/14/14		
The LSN(s) listed on this form have been Researched and Demil Code Verified as indicated above. The LSN(s) above have been authorized for release IAW DLA Dispo Svcs Policy.			
Printed CPB Certifiers Name		CPB Certifier Signature	
Printed CPB Verifiers Name		CPB Verifier Signature	
<small>Note: Please make sure you are reviewing Special Processing Requirements for item(s) that may require Special Processing. It is each Field Sites responsibility to ensure special processing requirements are met. Items that are not able to be Verified by CPB shall be downgraded according to Policy.</small>			

Figure 6. Researched Local Stock Number, 7/14/14 (from DLA DS, 2014)

Note: Ratio of LSN items researched in a week compared to total items received = Total LSN's researched (sum LSN in Figure 6) / total number of receipts for the week (weekly sum of receipts from Figure 7)

A	B	C	D	E	F	G	H	I	J
Jul	through....	7/31/14	sorted by Region, Site & Date	Point in Time	Point in Time		Point in Time		Point in Time
ADD New DAILY Data to bottom (Paste Values), then Sort by Region, Site, Date				RCN Open	RCN AGE	RCN to Induct (RCNs)	Backlog Ending (Lines)	Receipts (Lines + Batches)	Inventory Level (Lines)
Date	Region	Site ID	Site	Count	Oldest RCN	Days Avg	Backlog Count	Receipts	Inventory
7/2/14	West	RCCP	DLA DS PENDLETON	30	12	8.6	1,104	256	3,818
7/3/14	West	RCCP	DLA DS PENDLETON	30	12	8.6	--	375	--
7/4/14	West	RCCP	DLA DS PENDLETON	30	12	--	--	0	--
7/5/14	West	RCCP	DLA DS PENDLETON	30	12	--	--	0	--
7/6/14	West	RCCP	DLA DS PENDLETON	28	12	--	1,703	0	3,824
7/7/14	West	RCCP	DLA DS PENDLETON	31	13	9.9	2,320	231	3,812
7/8/14	West	RCCP	DLA DS PENDLETON	31	14	10.0	2,417	357	3,487
7/9/14	West	RCCP	DLA DS PENDLETON	34	13	7.9	2,507	311	3,508
7/10/14	West	RCCP	DLA DS PENDLETON	37	14	3.6	2,530	298	3,539
7/11/14	West	RCCP	DLA DS PENDLETON	37	14	8.5	--	273	--
7/12/14	West	RCCP	DLA DS PENDLETON	37	14	--	--	0	--
7/13/14	West	RCCP	DLA DS PENDLETON	40	17	--	2,538	0	3,568
7/14/14	West	RCCP	DLA DS PENDLETON	44	15	14.3	2,353	351	3,399
7/15/14	West	RCCP	DLA DS PENDLETON	47	16	12.5	2,108	333	3,477
7/16/14	West	RCCP	DLA DS PENDLETON	51	17	13.5	2,055	303	3,452
7/17/14	West	RCCP	DLA DS PENDLETON	51	18	12.5	2,099	301	3,014
7/18/14	West	RCCP	DLA DS PENDLETON	51	18	10.5	--	232	--
7/19/14	West	RCCP	DLA DS PENDLETON	51	18	16.1	--	401	--
7/20/14	West	RCCP	DLA DS PENDLETON	45	18	--	2,544	0	3,119
7/21/14	West	RCCP	DLA DS PENDLETON	47	19	15.4	2,446	157	3,096
7/22/14	West	RCCP	DLA DS PENDLETON	54	16	13.4	2,431	213	3,023
7/23/14	West	RCCP	DLA DS PENDLETON	59	17	6.4	2,410	107	2,993
7/24/14	West	RCCP	DLA DS PENDLETON	51	18	4.9	2,273	230	2,981
7/25/14	West	RCCP	DLA DS PENDLETON	51	18	6.4	--	401	--
7/26/14	West	RCCP	DLA DS PENDLETON	51	18	--	--	0	--
7/27/14	West	RCCP	DLA DS PENDLETON	52	21	--	2,456	0	2,918
7/28/14	West	RCCP	DLA DS PENDLETON	47	22	10.2	2,313	508	2,871
7/29/14	West	RCCP	DLA DS PENDLETON	49	23	13.7	2,383	432	2,877
7/30/14	West	RCCP	DLA DS PENDLETON	53	24	6.9	2,601	520	2,897
7/31/14	West	RCCP	DLA DS PENDLETON	62	25	13.7	3,072	140	2,927
Ratio of LSN items researched in a month compared to total items received					RATIO	0.0075	2,261	313	0.054

Figure 7. DLA DS at Camp Pendleton Daily Counts of Inventory Processed during July 2014 (from DLA DS, 2014)

Data presented in Figure 7 was analyzed to determine the effects of the Receipt Control Number (RCN) on input. Open RCN, RCN age, RCN to induct, ending backlog, running receipts and ending inventory are illustrated in columns E-J, respectively. Open RCN accounts for RCNs inducted to day and are being tracked. Oldest RCN indicated days oldest RCN aged; items are processed using the first-in, first-out method. RCN to induct indicates the average amount of days to process an RCN; per guidance it should be processed in three days. Backlog ending, reports an estimate amount of items that are stowed for future process. Receipts, reports total amount of items processed for the day. Inventory level refers to total amount of items in the warehouse that have been processed and are usable. The interest of this thesis is to analyze item input and objectively assess the output. Moreover, for this thesis, the amounts of employees are considered with regard to average per employee per hour that can processing items for disposal, thus the number of employees that are employed to process items impact the output. The

remaining items will be considered to be backlog for future processing. The coefficients are explained by the simple formula:

$$\text{backlog} = \text{input} - \text{output}$$

To illustrate backlog trend a broad understanding of the sales backlog formula was adapted and modified to illustrate items backlog rather than sales backlog (Bragg, 2012). The researcher sought to identify items' backlog worth of work days for a crew of six employees, therefore the sales formula was modified to fit DLA DS property backlog. The result is related to the rate of the estimated number of items received then stowed, and the rate of items processed. So, the backlog is the number of items that remain unprocessed in a time span. The formula is as follows:

$$\text{Days' worth of backlog} = \frac{\text{Backlog items}}{\text{Processed items per day}}$$

The ratio considers the number of items backlog divided by the number of items processed (receipts) per day. If the number of backlogged items is greater than the number of items processed (receipts), then the ratio will be greater than 1 day. This indicates that the facility receives more items and cannot keep up with more than the demand than it processed. Conversely, if the number of backlog items is less than the number of items processed (receipts), the ratio will be less than 1 day. This indicates that the facility can keep up with demand to process as many items as it receives.

Both data sets provided by DLA DS have relevance to this study because they contain metric measurements captured on a daily operational basis. Therefore, the data analysis provides meaningful empirical evidence to compare during the quantitative and financial analysis for the CBA.

c. Data Normalization Procedure

One of the most challenging tasks when collecting primary raw data is the data normalization process, because one needs to be careful not to adjust the data and change its empirical value. In order to attain better approximation of time-task-duration the

researcher drew from the Program Evaluation and Review Technique (PERT) and the Pearson Tukey formula to conduct data normalization. PERT estimates time in an uncertainty scenario and to best define the time mean and standard deviation for task duration the Pearson Tukey technique is appropriate (Klastorin, 2011). Both the standard deviation and the mean are assumed to be normally distributed.

Given that some the data collected was from a subject matter expert (SME), Klastorin (2011) suggested that experts have difficulty estimating with great accuracy. The SME at DLA DS in Camp Pendleton is the only trained verifier who has the credential to access databases to conduct the item research. Therefore, the verifier is within bounds for the author to rely on his expert opinion. However, Klastorin (2011) further suggested utilizing the Pearson Tukey technique to reduce subjectivity in the SME's opinion. The Pearson Tukey formula considers error in the estimation's mean and variance calculations. The resulting formula consider these factors, as shown below:

$$\text{Mean Task Time} = t_{50} + 0.185(t_{95} + t_5 - 2t_{50})$$

$$\text{Standard deviation} = (t_{95} - t_5)/3.25$$

where: t_{50} = median

t_{95} = 95th Percentile

t_5 = 5th Percentile

Traditionally, the Monte Carlo simulation approach computes the probability safety lead-time that the task will be completed on time (Klastorin, 2011). Therefore, in the search to fully estimate a task's time completion, this study used the Monte Carlo technique. Furthermore, the researcher used the Crystal Ball add-on application to Microsoft Excel to simulate the scenario for 10,000 times. Then, a lognormal distribution parameter was used in order to get positive time result as only non-negative values are meaningful in this case. The distribution is skewed because it doesn't give negative date and time that are not possible occurrences (GAO, 2009b). Figure 8 presents the distribution parameter's description and application justification.

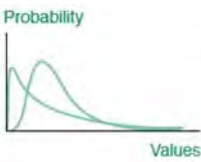
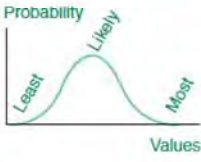
Distribution	Description	Shape	Typical application
Lognormal	A continuous distribution positively skewed with a limitless upper bound and known lower bound; skewed to the right to reflect the tendency toward higher cost		To characterize uncertainty in nonlinear cost estimating relationships; it is important to know how to scale the standard deviation, which is needed for this distribution
Normal	Used for outcomes likely to occur on either side of the average value; symmetric and continuous, allowing for negative costs and durations. In a normal distribution, about 68% of the values fall within one standard deviation of the mean		To assess uncertainty with cost estimating methods; standard deviation or standard error of the estimate is used to determine dispersion. Since data must be symmetrical, it is not as useful for defining risk, which is usually asymmetrical, but can be useful for scaling estimating error

Figure 8. Probability Distribution Description Shapes and Application
(from GAO, 2009b)

Finally, adjusting the data for uniformity to actual cost is considered. Given that some of the data was generated in 2008 and other data in 2013, normalization is required. Similarly, the historical dollar value data must be normalized for inflation. Therefore, the researcher used the military construction (MILCON) inflation factor to convert the funding profiles and determined the then year (TY) into fiscal year 2014 (FY14) to establish a baseline of cost. Additionally, the default setting “Show empty data as zero” was enabled in Excel to automatically treat blanks cells as zero. Appendix B showcases the treatment of empty cell the method. Furthermore, the results from the data normalization were used to estimate the time-task-duration to account for it in the CBA section of the thesis.

The following disclaimer should be noted: Crystal Ball is licensed for educational purpose by The Naval Postgraduate School; therefore, the Crystal Ball charts contain the statement “Not for Commercial Use.”

In summary, normalizing reduces dispersion of data points and maintains constant and accurate information. Therefore, it is imperative to adapt the method and techniques described in this section in order to be applied in this study.

C. TECHNOLOGY READINESS METHODOLOGY STEPS

Using the TRL table established in Chapter II, this study provides results of the three companies. According to the GAO (2003), the TRL tool is used to assess technology's maturity. The TRL methodology is widely known in the DOD for its best practice approach of ranking technology's maturity. The benefit of evaluating three companies' technology provides controls to reduce the risk of running the project over schedule and over budget. The foundation to make the technology assessment using the TRL tool was outlined in Chapter II.

In this study three commercial-off-the-shelf object/shape recognition tools were evaluated. This study followed the TRA skeletal template from the DOD TRL Guidance and adopted the DOE report format. The COTS with the highest TRL will be recommended for further maturation. The TRA report consists of the following information:

1. Overview of object/shape recognition technology profile.
2. Technology's goal with regard to what it does and affects.
3. Benefits with regard to how the technology benefits businesses that use it.
4. Critical area(s) of challenge such as finding a demonstration and any risk implementing it at DLA DS.
5. Qualitative summary of technology's technology readiness level (TRL) using the TRL table in Chapter I.
6. Statement of relevancy to DLA DS, which provides a conclusion with supporting evidence or rationale and dissenting opinion of technical aspects information that may be deemed pertinent to support the decision-maker.

1. Data Sources for Technology Readiness Level Assessment

The researcher visited three companies during the months of August to collect data to assess the technology maturity of three products. The researcher spent one half day at each of the company. The researcher observed demonstrations of the technology products at each firm, taking detailed notes and asking clarifying questions to develop a deep understanding of each product's capabilities. The researcher also collected

presentations of the technologies, and white papers, pamphlets and videos describing the technologies. This data is summarized in Table 2.

Table 2. Data Collected from Companies

Company	Data	Quantity
COGNEX	Pamphlet	2
COGNEX	Video from YouTube	5 minutes
Imaginestics	Pamphlet	2
Imaginestics	Pictures	10
Imaginestics	PowerPoint (1)	10 slides
Imaginestics	Video	20 minutes
RMD	White paper	1

Overcoming Data Challenges: The researcher gathered the primary data and information used for this study during business trips. The purpose of the business trips was to observe and assess the technology's maturity, and conduct a cost evaluation. The researcher visited three potential companies of interest and communicated via telephone and email with three other companies. Admittedly, there were challenges in gathering actual technology costs posed by the companies' leadership due to proprietary technology rights, privacy policies and reluctance to advertise actual cost without negotiating a contract. However, one company did provide examples of costs for use in this thesis. Finally, the researcher believes that the evidence obtained during the study provided reasonable basis to provided reasonable accurate information in order to make an informed analysis conclude with recommendations. The study does not endorse one specific company over another. The intent of the study is to offer DLA DS decision-makers as much information relating to what the commercial sector has to offer on object/shape recognition technology as possible, so that they can make the most informed decision about implementing technology to their property identification process.

D. COST BENEFIT ANALYSIS METHODOLOGY STEPS

The CBA considers which alternative provides the highest positive tangible and intangible realized net benefits. The CBA is an analytical tool to support the decision-

making process when choosing between competing alternatives. A sensitivity analysis supports the CBA by changing assumptions to understand risk factors that alternatives inherit. Boardman et al. (2011) proposed the analysis to calculate social benefit for each alternative: net social benefit (**NSB**) equals social benefit (**B**) minus social cost (**C**).

$$\text{NSB} = \text{B} - \text{C}$$

According to Boardman et al. (2011), there are three major types of CBA and one comparative class of CBA:

1. Ex ante CBA: conducted prior to the project; useful to show whether resources should be allocated for a particular project.
2. Ex post CBA: conducted at the end of the project; provides information about the particular class of project.
3. In medias res CBA: conducted during the project.
4. Comparative CBA: compares the ex ante predictions to ex post results for the same project.

This research study used the ex ante CBA to provide information to DLA decision-makers prior to making an investment. Notwithstanding, there are nine basic steps in conducting a CBA (Boardman et al., 2011, p. 6), which will be applied in the methodology chapter. The details of all the steps for CBA are detailed in the sections that follow:

Step 1: *Specify the set of alternative projects.*

Step 2: *Decide whose benefits and costs count (standing).*

Step 3: *Catalog the impacts and select measurement indicators.*

Step 4: *Predict the impacts quantitatively over the life of the project.*

Step 5: *Monetize (attach dollar values to) all impacts.*

Step 6: *Discount benefits and costs to obtain present values.*

This analysis normalized the wages data for inflation. Therefore, a nominal discount rate is used to discount cost and benefit over the 10-year horizon time.

Furthermore, in order to account for the time value money, this research used a 7% discount rate. According to the Circular A-94, when analyzing proposed investment the 7% rate is ideal for calculating the return on investment in the private sector (OMB, 1992).

Step 7: *Compute the net present value of each alternative.* The net present value (NPV) equals the present value of benefits minus the present value of costs:

$$\text{NPV} = \text{PV (B)} - \text{PV(C)}$$

Choose the alternative with the largest NPV.

Step 8: *Perform sensitivity analysis.* To shield from uncertainty of the predicted impact, this study conducted a yearly variance sensitivity analysis using the 5% lower bound and 90% upper bound confidence intervals.

Step 9: *Make a recommendation.* The results from the NPV calculation with the alternative with the largest NPV will be the criterion for recommendation. This will also consider the sensitivity analysis to make recommendations.

For this thesis, the status quo alternative is compared with the option to implement new object/shape recognition technology. This thesis builds upon this generally accepted approach to fully analyze the costs and benefits associated with implementing object/shape recognition technology at DLA. As a general rule, CBA is created for a comprehensive analysis.

1. Assumptions, and Data Sources for Cost-Benefit Analysis

The following data and assumptions are used for conducting the cost benefit estimates.

a. Assumptions

In order to estimate benefits generated by the implementation of an object/shape recognition technology, this thesis uses the opportunity cost approach. In essence, the benefits associated with the new technology are estimated as savings in labor costs that

do not have to be paid out any longer once the labor-intensive status quo is replaced. Although DLA DS is a non-profit organization, the researcher is able to use the market comparable approach to calculate the return on investment. While DLA DS does not have an overall comparable commercial market force to compare revenues, the above assumption allows the researcher to use the market comparable labor rates as a form of estimating revenues (Housel et al., 2007). In order to conduct a break even or return on investment analysis, Jegers (2008) suggested calculating earned revenues from other sources rather than sales. Therefore, there seems to be no reason to use the current general schedule (GS) wages as market comparable revenues. The researcher calculated the annual wages in dollars per hours in order to monetize the LSN research task, the assumption being that automating the identification process with technology will save money in labor cost and increase productivity. Additionally, implementing object/shape recognition technology will not replace the bar code readers because implementing object/shape technology is for the identifying items without information. Furthermore, the scope of this thesis limits the amount of variables one can research and utilize in accounting for how the technology will generate more market comparable revenues.

b. Data on Employee Wages and Number of Disposal Operations Employees

The researcher drew from the GS pay chart to indicate the average labor rates for employees who conduct disposal services at DLA DS, Camp Pendleton, California. The cost of labor is used to conduct the NPV to satisfy a market comparable approach in terms to calculate the return on investment. The GS pay table is illustrated in Figure 9.

SCHEDULE 1--GENERAL SCHEDULE

(Effective on the first day of the first applicable pay period beginning on or after January 1, 2014)

	1	2	3	4	5	6	7	8	9	10
GS-1	\$17,981	\$18,582	\$19,180	\$19,775	\$20,373	\$20,724	\$21,315	\$21,911	\$21,934	\$22,494
GS-2	20,217	20,698	21,367	21,934	22,179	22,831	23,483	24,135	24,787	25,439
GS-3	22,058	22,793	23,528	24,263	24,998	25,733	26,468	27,203	27,938	28,673
GS-4	24,763	25,588	26,413	27,238	28,063	28,888	29,713	30,538	31,363	32,188
GS-5	27,705	28,629	29,553	30,477	31,401	32,325	33,249	34,173	35,097	36,021
GS-6	30,883	31,912	32,941	33,970	34,999	36,028	37,057	38,086	39,115	40,144
GS-7	34,319	35,463	36,607	37,751	38,895	40,039	41,183	42,327	43,471	44,615
GS-8	38,007	39,274	40,541	41,808	43,075	44,342	45,609	46,876	48,143	49,410
GS-9	41,979	43,378	44,777	46,176	47,575	48,974	50,373	51,772	53,171	54,570
GS-10	46,229	47,770	49,311	50,852	52,393	53,934	55,475	57,016	58,557	60,098
GS-11	50,790	52,483	54,176	55,869	57,562	59,255	60,948	62,641	64,334	66,027
GS-12	60,877	62,906	64,935	66,964	68,993	71,022	73,051	75,080	77,109	79,138
GS-13	72,391	74,804	77,217	79,630	82,043	84,456	86,869	89,282	91,695	94,108
GS-14	85,544	88,395	91,246	94,097	96,948	99,799	102,650	105,501	108,352	111,203
GS-15	100,624	103,978	107,332	110,686	114,040	117,394	120,748	124,102	127,456	130,810

Figure 9. General Schedule Pay Table for 2014
(from Executive Order No. 13,655, 2013)

The DLA DS at Camp Pendleton structure was collected to identify how many employees are part of the disposal operations. During the study, two positions were vacant as illustrated in Table 3. The two employee functions include the Disposition Services Representative (DSR) supervisor or a DSR, the pay plan is under the GS rules in accordance to the series standard 1104 classifying the employee as a Property Disposal Clerical or Technician pay grade hired under the available positions.) In this case, the grades are GS 9 through GS12. Figure 9 identifies wages for every respective position. For this study, the GS 11 is step 6, whose salary is \$59,255, consistent with the pay scale the verifier at Camp Pendleton holds.

Table 3. DLA DS at Camp Pendleton, California, Disposal Operations
Structure as of July 2014 (from DLA DS, 2014)

Disposal Operations Structure				
Vacant/Full	Function	Pay Plan	Series	Grade
Vacant	DSR Supervisor	GS	1104	12
Full	DSR	GS	1104	11
Full	DSR	GS	1104	11
Full	DSR	GS	1104	09
Vacant	DSR	GS	1104	09
Full	DSR	GS	1104	09
Full	DSR	GS	1104	09
Full	DSR	GS	1104	11

E. SUMMARY

This chapter outlined the foundational method for conducting the CBA in order to make informed recommendations. This chapter described the steps taken to analyze the item processing; including the method used to normalize the data to ensure uniformity and integrity. The chapter also presented the assumptions and data sources for the cost benefit analysis. The researcher took into account that collecting data from a SME has biases such that to reduce their opinion's subjectivity the Person Tukey is an appropriate formula to consider for error. The next chapter will present the analysis of DLA DS's purpose and operational method, and discuss the assessment results on COTS of objects/shapes recognition technology.

IV. ANALYSIS OF THE CURRENT PROPERTY PROCESS AT DEFENSE LOGISTICS AGENCY DISPOSITION SERVICES AND MATURITY ASSESSMENT OF OBJECT/SHAPE RECOGNITION TECHNOLOGY

In support of the DLA mission and vision, DLA Disposition Services supports the Warfighter and protects the public by providing worldwide reverse logistics solutions. Our goal is to become the Department of Defense's Reverse Logistics Center of Excellence

—DLA Disposition Services Transformation Plan 2014–2019

A. OVERVIEW

Chapter III explained the method by which this thesis explored the organization process with Defense Logistics Agency Disposition Services (DLA DS). This chapter presents the background on DLA DS management's concerns to contextualize this study, and presents and discusses the results of that analysis of the current property process at DLA DS. In addition, this chapter provides an overview of DLA DS' purpose, operational process activities, and managements' concerns and details the results from the assessment on objects shapes recognition technology prototypes from three companies.

1. Introduction

On September 1972, the Disposition Services (DS) was established as a division of the Defense Logistics Agency (Grasso, 2014). The mission of the DS is the management of the DOD's assets that have reached the end of their life cycle. Specifically, DS focuses on solutions to dispose property no longer wanted from all the Marines, Army, Navy, and Air Force, and other federal agencies. Today, the DLA DS management is interested in improving the efficiency of the item processes. One potential way to improve efficiency of the DLA DS processes is the use of object/shape recognition technology, identifying as a way to reduced costs by DLA DS (2008) study. This section describes the DS purpose and motivation for considering technology to achieve DLA DS goals and underlines the property identification process, inefficiency, problems with the processing system that creates backlog, and analysis to resolve the

backlog issue. To illustrate the points, observations made by the researcher during the visit at the DLA Disposition Services at Camp Pendleton, California, will be provided.

2. Defense Logistics Agency Disposition Services Activity

a. Disposition Services Purpose

The DS provides support to the DOD in 109 different locations worldwide that including 15 countries and 41 states, employing over 1,500 employees. DS Headquarters is in Battle Creek, Michigan, its location meant to control and support its mission (DLA DS, 2013).

The broad purpose of a DS network is to facilitate the DOD in property disposal around the world. DS calls the services “reverse logistics.” *Reverse logistics* is defined as the operations that accept property from the branches of services to screen it for redistribution (DLA DS, 2013). To manage accountability and control around the world, DS’s purpose statement says the following:

Our purpose is to serve as the Reverse Logistics provider for the Department of Defense to include services for the disposal of material no longer needed for national defense, comply with legislative and regulatory requirements, protect the public from dangerous defense items, and pursue maximum value for tax dollars. Our Reverse Logistics capacity includes responsibility for property reuse (including resale), hazardous property disposal, demilitarization, precious metals recovery and recycling program support, worldwide. Reverse Logistics is more than property disposal; it is the process of planning, implementing, and controlling the efficient, cost effective flow of excess materials, in-process inventory and related information from the point of declaration of excess for the purpose of recapturing value or proper disposal. (DLA DS, 2014a, p. 1)

Reverse logistics includes the following disposal choices: reuse; transfer property within inter branch of service; donate property to state, local or non-profit organization and sell it to the public; or destroy it to turn it into scrap to prevent further use. Consequently, DS goals are aligned with the DLA to accomplish the reverse logistics purpose.

b. Motivation for Considering Technology

As important as DS is to the DLA, the DLA director requires that all divisions “Improve process and productivity” in order to become responsible stewards of taxpayer’s dollar (DLA, 2014). Additionally, DS has the added pressure of fiscal obligations and budgetary cuts such that DS continuously pursues decreasing operations cost. Therefore, goal achievement and sustainment is of DS top priority, so factors that affect operation cost are continuously examined.

To accomplish reductions of operations cost, DS conducts studies to identify any cost-reducing opportunities. In 2008 (DLA DS, 2008), a study to change the 20-step property acceptance process was concluded at one of DS’s facilities located in Stockton, California. The study resulted in streamlining the process to seven steps using the Lean Six Sigma logic. The change in process resulted in time savings equivalent to 40% (DLA DS, 2008). The study concluded with a recommendation for a future study to exploit wireless capabilities (DLA DS, 2008).

This thesis aims to analyze DS item process, conduct a technology readiness assessment and conduct a cost benefit analysis in effort to finding a solution to improve the process with technology. To achieve this goal, this thesis adopted two DS strategic objectives set by the DLA DS Director Transformational Plan 2014—2019:

1. Embrace innovation and leverage industry: “Employ industry and academia to pursue technological advancement in reverse logistics solutions” (DLA DS, 2014a, p. 10).
2. Identify opportunities for process enhancement to reduce cost: “Optimize Network to provide accountable, compliant, and agile property handling (internal operating system strategy)” (DLA DS, 2014a, p. 10).

3. Property Disposal Process

In 2008, efforts to improve the property process resulted in a streamlined process that saved time through the lean approach. Currently, DS continues to process property using the Lean Six Sigma standards. However, DS recognizes that the improved seven-step process can be tweaked; therefore, DS is interested in additional improvements.

Hence, in order to seek improvements, one needs to understand the process flow to identify inefficiencies, drawbacks, and problems.

DS manages property for disposal and the choices include one of the following: reutilization, transfer, donation, resale and ultimate disposal as scrap. In this context, the holistic process is depicted in Figure 10.

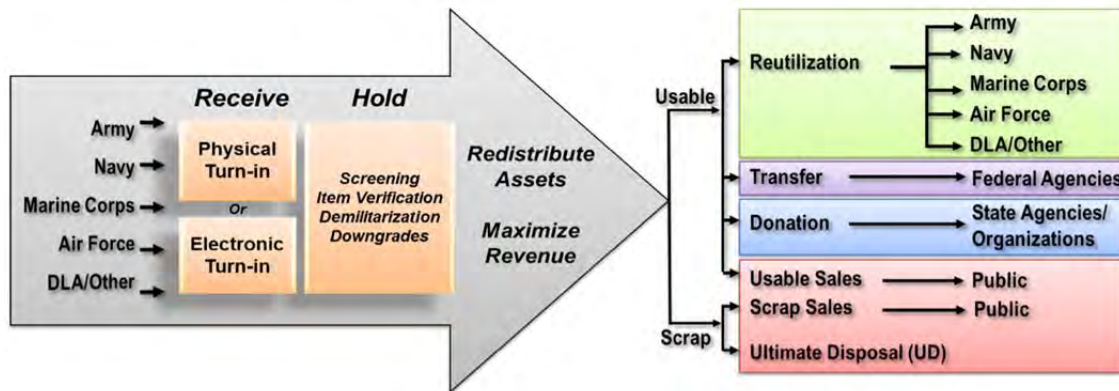


Figure 10. Disposition Services Process Disposal Overview (from DLA DS, n.d.)

Figure 10, presents the overall flow of property acceptance conducted at DS. The items are received from all four branches of service—Army, Navy, Marine Corps and Air Force—and other federal agencies. Then the items are individually screened for proper disposal decision. Some of these items are redistributed for reutilization by any branch of service or transferred to federal agencies. Major recipients of donated items go to state and local agencies, like the fire department or police stations. Additionally, some items that are safe for public use are sold through public auctions and scraped items are sold through business partners. Finally, items that cannot be sold to the public due to potential hazard or to prevent putting them into the hands of an adversary are mutilated or stored in military facilities.

The property disposal process begins when the customer completes the mandatory disposal turn-in document (DTID), DD Form 1348 1A, and associated certificates depending on the type of property (further details about how the document is generated is emphasized later in the section). The property is accepted from the customer as a

conveyance and tagged with a receipt control number (RCN). The RCN identifies the customer, tracks the time it takes to process the items, reduces dual effort, organizes for precedence processes, order, and optimizes limited resources. Conveyance is then tracked and identified as an RCN.

Turned-in property at DS arrive in pallets, triwalls full of line items (LIs) or single LI. DS employees are hired in any position under the Deposition Service Representative (DSR) and are known and referred to full-time employees (FTEs). FTEs store the RCN property that cannot be inspected for disposal decision upon arrival, and at that moment it becomes backlog for future process in precedence of arrival. Items that are inspected on a daily basis are broken down into individual LIs, and then the usable property is retained for 42 days of screening. During the screening phase, the retained property is marketed for reutilization, transfer, or donation (RTD) to the branches of services, or local or federal agencies, as noted in Figure 1. After 42 days, the LI that is not RTD is handled again and turned over to government liquidations contractors to sale to the public. Property that requires demilitarization (DEMIL) is only available for a 14-day period per the DOD screening cycle and then sent to a DEMIL site for proper disposal and destruction. DEMIL property is not made available for public sale. Figure 14 illustrates a timeline of the process.



Figure 11. Disposition Services Process Disposal Timeline (from DLA DS, n.d.)

Figure 11 displays the days required to accomplish property disposal. The RTD activities occur between days 1 and 42. In the *incubation* period, days 1–7, LI is pending screening to decide appropriate disposal. Annually, on average, RCNs wait 7.6 days to be processed for screened for demilitarization or downgraded for scrap. During the *reutilization-screening* period, 1–14 days, LIs are screened for the RTD program. During the *transfer-screening* period, the LI is initially requested to be RTD. During the

donation period, 36–40 days, LIs are released under the RTD program for reuse. These items can then be transferred to the federal agency that needs it. The law authorizes these transfers to federal agencies, state agencies, or police stations. Additionally, items can be donated to non-governmental agencies or humanitarian aid organizations. Annually DS takes, on average 32 days to ship out under a document identifier form Materiel Release Order (MRO). Between 40 and 42 days, *last chance*, are the last days items can be requested for RTD by any branch of service, state agency, or local agency. Finally, during *ultimate disposal (UD)*, the end of the cycle, some property can be sold to the public when it is deemed safe for sale, destroyed, or transferred to a long-term storage facility. The flow diagram (see Figure 12) provides amplifying explanation that occurs at every step of the disposal process.

DISPOSITION FLOW DIAGRAM

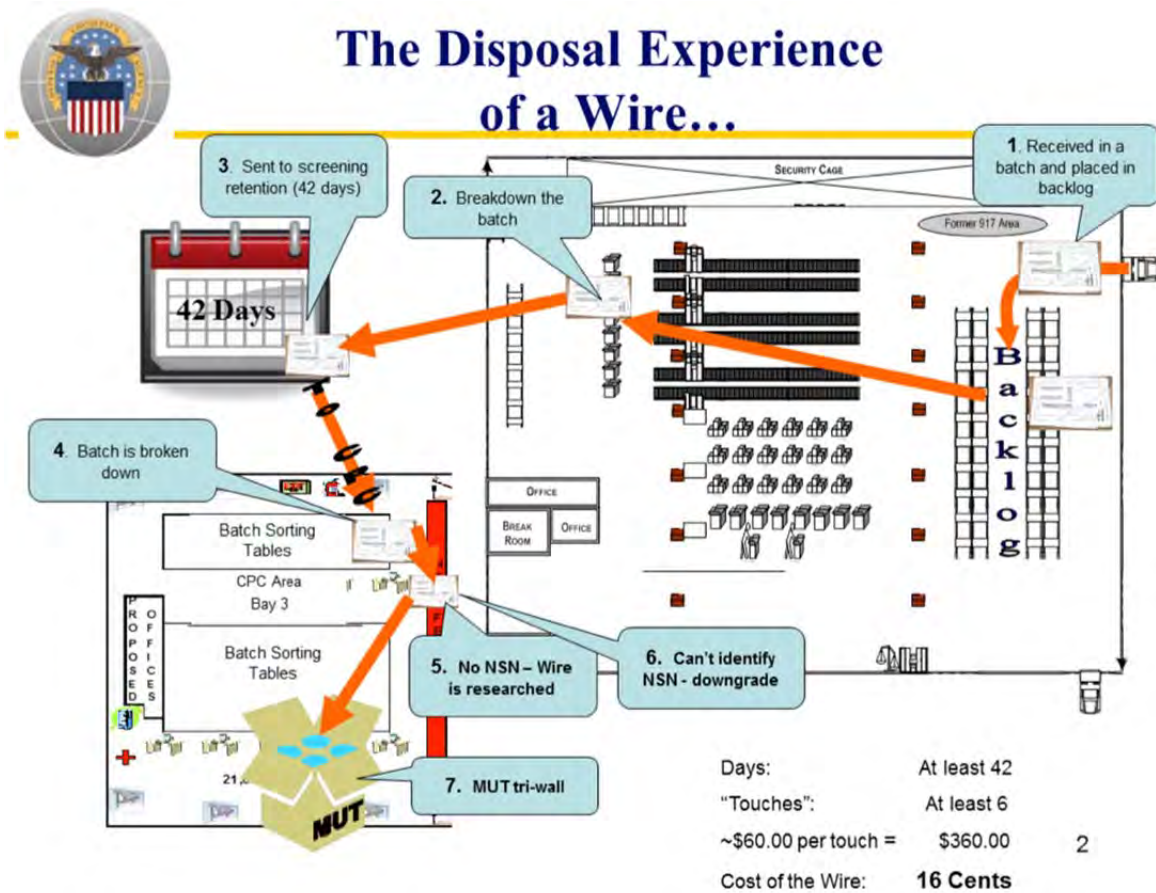


Figure 12. Process Flow Diagram of Items Turned in for Proper Disposal (from DLA DS, 2008)

All items turned in for disposal at DS go through these internal sequence of events: (1) receive items received into conveyance and issued RCN to store in backlog storage, (2) conveyance broken down, (3) screening, (4) item sorting, (5) unidentified item research is conducted, (6) code for disposition identified, (7) boxed in tri-wall containers for final life cycle procedure. The process depicted in Figure 12 provides the steps the LIs undergo. All items turned in undergo through this cycle:

1. Receive items: Conveyance is tagged, but it may have up to 50 individual line items. Approximately 70% of all LIs received are downgraded upon receipt for sale as scrap by weight (DLA DS, 2014a).

2. Breakdown the conveyance: Batches are itemized into individual LIs for inspection. This accounts for the remaining 30% of LIs. These LIs end up in the RTD pipeline.
3. Screen: As noted above, the RTD screening process includes a “42-day staggered availability period that offers property for reuse first to DOD consumers; next other federal government consumers and last, the property is available for donation to authorized nonprofit organizations” (DLA DS, 2014a). After 42 days, the items are sent to the Control Property Center (CPC) for sorting. Figure 11 presents the screening timeline.
4. Sorting: Batches are sorted, identified for restrictions to sell it to the public use demilitarized (scrap) or long term storage.
5. Managed unidentified item: The FTE verifies and conducts research using one or all three databases (i.e., Federal Logistics Data and FLIS = Federal Logistics [FEDLOG], WebFLIS and Haystack).
6. Code for disposition: The items that cannot be verified are downgraded to a scrap category.
7. Managed boxed-in-tri-wall containers: Items with codes: demilitarized or mutilate (MUT) for total destruction to the point of scrap are boxed and sent to the nearest Centralized DEMIL Division (CDD).

After 42 days, in the last three steps of the process, the FTEs screen items for ultimate disposal. Steps 5 and 6 illustrated in Figure 3 are the focus of this project. Step 5 is a crucial step because time, resources and money are consumed because the FTE conducts research. In Step 6, the FTE decides to scrap unidentifiable LIs. Conversely, when LI information is discovered, the FTE determines to give the LI one more opportunity to RTD.

In all, the items are disposed through RTD, resale, scrap, or long-term storage. There is no shortage of available LIs as items continuously arrive. Similarly, at the other end of the process items are disposed but sometimes with challenges. Where does the

disposed property end up? According to DLA DS (2014a) these items have a final destination and the percentages are explained:

Of the total items that enter the disposition process, approximately 85% of items are disposed as scrap or Hazardous Waste (HAZMAT), 6% of items are claimed during the RTD screening cycle and 9% of the items are eventually sent to sales when not requested for reutilization. This type of property includes Hazardous Material (HAZMAT), Hazardous Waste and items with specific DEMIL requirements, all of which are handled under specialized rules. A fraction of the items that are identified as DEMIL coded “B” or “Q,” (due it being hazardous to release to public), are sent to Long Term Storage. (DLA DS, 2014a, p. 7)

In summary, in 2008, the efforts to improve received property resulted in a streamlined process that saved time. Currently, DS continues to process property using the Lean Six Sigma standards. DS recognizes the improved 7-step process can be tweaked; therefore DS is interested in additional improvements. The next section provides observations that aim to identify any inefficiencies, challenges, drawbacks and problems with the property process.

a. Inefficiencies

From a qualitative perspective, the current process requires multiple “touches” of the property including handling, segregating, processing, and shipping. This relatively “high touch” and risk adverse environment is inefficient, costly and burdensome to our customers and ourselves and must be reduced.

—DLA DS, 2014a, p. 7

The previous sections described the disposition process and the goals to cost savings associated with improving the item disposition process. However, some of these efforts have been challenged with the ongoing inefficiency to effectively identify LIs. Examining the operational flow in Figure 3 reveals where potential challenges and “bottlenecks” are created. The results of the analysis, it turned out, show that researching items is not the only area of concern with regard to process inefficiency. About less than 1% of accepted items at DS facility in Camp Pendleton are unlabeled which creates for an additional time to research the missing information. Actions to dispose of LIs may be slow due to the inaccuracy of information recorded in the DTID, accepted LI is obsolete

and risk adverse culture creates drawbacks and impacts progress. Additionally, a greater number of accepted items may be more than the amount of items that are processed on a daily basis. This inefficiency is precisely quoted above and cited from the DLA DS' Transformation Plan 2014–2019 (DLA DS, 2014a).

In general, items that are properly marked occur when the disposal request, DTID, is generated via the Dispositions Services' website or the Distribution Standard System (DSS), which comes from Federal Logistics (FLIS). DSS is the automated property accounting and inventory management system used by DS to process personal property through the disposal cycle (DLA DS, 2013c, p. 1). When inputting a DTID with a valid NSN into DSS, the system automatically populates the corresponding DEMIL code that has been assigned in FLIS. If the screen shows a DEMIL code that is different from what is believe the code should be, then the customer can make corrections to enter the proper information and that alert allows for verification to correct for coding errors so that the proper item is submitted for disposal. According to the DLA DS training manual, there are benefits for filling the DD 1348 through the web-based Electronic Disposal Turn-in Document (ETID) program:

ETID allows the customer to electronically submit turn-in documentation to the disposition services site. This program will pre-populate many of the fields for NSN items, nomenclature, DEMIL code, unit price, etc. It includes drop down menus for other fields for quick reference. In addition to electronically preparing your turn-in documentation, the program allows printing a completed DD 1348–1A, shipping paper, required DEMIL certifications, and bar codes the DD 1348–1A. One of the benefits of using ETID is that it allows the disposition sites to review the turn in paperwork prior to physical movement of the item and any questions can be quickly resolved. ETID requires an account to be established with user id and password. (DLA DS, 2014b, p. 20)

In contrast, there are some anomalies in the documentation's accuracy when is handwritten. The DLA DS website is able to properly correct for errors, whereas handwritten documents prepared by the customer at the generating activity may not have all or accurate information. Nonetheless, DD 1348s are manually corrected, as noted in Figure 15, but the progress is sluggish when items without documentation or marking tags, or that are obsolete, are accepted in the facility. According to DLA DS standard

operation procedure (SOP) “Disposition Service Customers may turn property in manually or electronically via ETID. Customers who manually prepare the DD Form 1348–1A should be encouraged to use ETID. ETID will simplify and reduce Generator time processing items for turn-in” (DLA DS, 2013c, p. 4).

Figure 13 illustrates two different scenarios: on the left, items are properly marked and DD 1348s are enclosed in the packing protector; and items on the right side of the figure are items on a pallet without DD 1348 forms.



Figure 13. Properly Labeled Items and Unlabeled Items
Note. The pictures were taken by the researcher in DLA DS at Camp Pendleton, California, in July 2014

DS' item process faces efficiency challenges and an additional FTE position—Verifier, is established. The verifier researches information in order to identify unmarked property. Some of the challenges posed are rapidly finding information for obsolete items due to their arrival at DS without manufacture information and part number. The difficulty with obsolete items is that electronic information is not readily available. Proper identification consumes the verifier's time in searching for the information on the Internet or various databases. For example, the verifier at DS at Camp Pendleton conducts research on the Internet for items that do not have paperwork or may have only

a local stock number (LSN). An LSN stock is an identification code generated by the owning unit prior to being turned in to DS. However, the code is not linked to the actual part number, manufacturer or national stock number (NSN) information, because the owning unit may not have had that information in the first place. This disparity of information leads to adding additional steps in the disposition process that can result in additional time to the process. On average, the verifier spend about 13 minutes to research an item's information. Figure 14 shows the results for task mean time calculation.

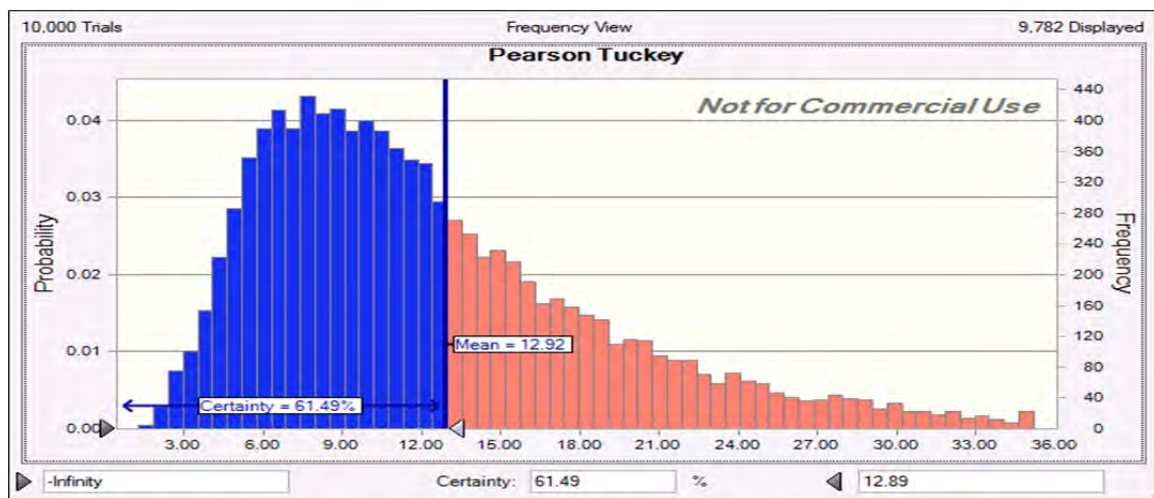


Figure 14. Computer Generated Task Time using Expert Opinion and Pearson Tukey Formula

Figure 14 shows a simulation of the task time, using a Monte Carlo simulation on the Crystal Ball (CB) application. The estimate given by the DS specialist verifier was a time requirement of 5–10 minutes to finish the task. However, the verifier claims to have taken him up 30 minutes. By using the Pearson Tukey formula to take into account any expert error, and running the Monte Carlo simulation on CB, the findings show that the chance of finishing the task in 5–10 minutes is about 8–43%, respectively, and the chance of finishing the task in 30 minutes is about 3.5%. However, CB shows a 61% chance of finishing the task in 13 minutes. Therefore, the 13-minute mean time is used for this analysis. The lognormal curve gives the probability of finishing the task at any particular

time. According to the Oracle® Crystal Ball's guidebook (Oracle® Crystal Ball, Fusion Edition, [Version 11.1.1.1.00], n.d.), the results in the diagram are interpreted as follow: the forecast chart (the x-axis value that is the mean) frequency of about 280, meaning that the interval expressed by that column contains 280 values. The mean has a probability of less than 0.03 (or 3%), meaning that there is a 3% chance of a value falling within this interval. The certainty range includes all values between -Infinity and +Infinity. The certainty level is 100%. The display range excludes only one trial out of the total 10,000.

The DS at Camp Pendleton has currently one verifier who conducts the research of identifying items. However, management acknowledges that utilizing an additional employee could alleviate the overwhelmed single verifier. One verifier is a single point of failure. For example, in the absence of the verifier no one can pick up and continue to conduct the research because the other employees are not trained and do not have access to the password-enabled databases. Therefore, the verifier is the only one who has been granted access to the commercial website, Haystack. This website is a contracted web search engine for a limited number of users across DS. Nonetheless, researching unidentified items for proper decision disposal is a way to reduce a risk. Safety is always considered when getting rid of items so militarized items do not end up in the enemy's hands or exposing hazard to the public. DLA's core mission is to "protect the public." Figure 15 displays the Haystack on a computer screen. The verifier finds and writes the disposal information that was missing on the DD 1348 using Haystack. The verifier claims to spend an average time of 10–15 and up to 30 minutes researching items consuming a half day's work. So, for the purpose of this research the 13-minute task time per item is utilized, consistent with the computer-generated forecast model.

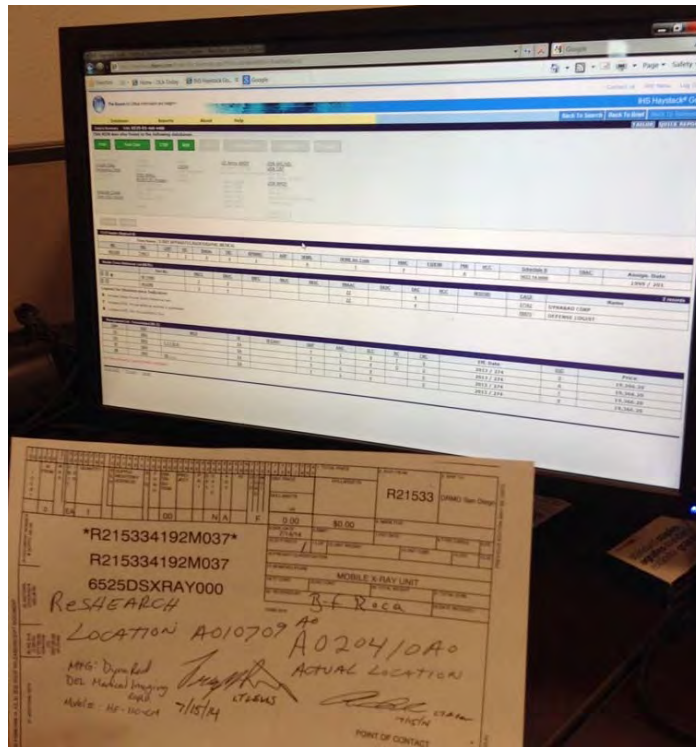


Figure 15. Filled Disposal Turned-in Document with Local Stock Number Information and Reached on Haystack website
Note. The picture was taken by the researcher in DLA DS at Camp Pendleton, California, in July 2014

Figure 15 displays a DD 1348 with the printed LSN, but the handwritten information was researched by the verifier in Haystack. Figure 15 illustrates the paper DTID, with the item's LSN typed the information was researched in the Haystack web-based contracted program.

Due to their nature, disposed military items that may pose some risk to the public. The effect is that it has cultivated a risk adverse culture, and management would much rather invest time identifying items rather than selling them as is. According to the Receiving SOP (2014c), items are “challenged,” per se, for further investigation and verifiers utilize all available resources. For example, the verifier encounters the following situation and follows this procedure:

When to challenge—the first test of whether the DEMIL code of an item should be challenged is made by comparing the DEMIL code on the DTID [DD Form 1348] for the item and the item itself to the DEMIL code in

Distribution Standard System (DSS), which comes from FLIS. If these are not in agreement, the DEMIL code may need to be challenged. Research must be performed to determine what the correct code should be according to the established guidelines in the DEMIL Manual. (DLA DS, 2014c, p.7)

Selling an unidentified item without disposition instructions could potentially be unsafe to the public. Furthermore, this process ensures that items do not end up being reused as weapons by adversaries. Therefore, management ensures high effort is spent researching the items (Inspector General of the Department of Defense, 2013).

With a risk adverse-culture, employees exhaust their means to ensure that they have disposition codes. However, this creates a drawback regarding time allocated to one item. Excess time spent on one item can be a contributing factor to creating a backlog. Another drawback is that, within the levels of security measures, items end up in the scrap pile for disposal and miss an opportunity for resale. These measures are taken for safety reasons. Nevertheless, slow and inaccurate identification reduces timeliness of an item's disposal and the opportunity to continuously process more items. The ratio of LIs researched in a week compared to items received is calculated by the following formula:

Ratio of LSN items researched in a month compared to total items received = Total LSN's researched (sum LSN in Figure 6, see Chapter III) / average number of receipts for the month (month sum of receipts from Figure 7, see Chapter III)

Therefore, information from Figure 6 and Figure 7 in Chapter III is used to estimate the average amount of items and time spent for the month of July researching:

$$0.0024 = 17/7196$$

In other words, less than 1% of accepted items in July were researched. Despite the low percentage, it took about 3.6 hours to investigate the information in order to properly dispose of the 17 items.

$$221 \text{ min} = 17 \text{ items} \times 13 \text{ minutes}$$

Conversely, the verifier downgrades to scrap the items when too much time is spent. This generates a missed opportunity because the items may actually have some

recoverable value. Moreover, the opportunity cost is in the form that DLA DS either decides to pay a contractor to scrap the items that may still have some recoverable monetary value if sold in the commercial sector, or incurs holding costs when items are stored in warehouses. The benefit of identifying all items upon arrival at DS provides a leverage point to reuse or resale more items rather than destroying them. Thus, reselling items returns revenues to the DOD.

b. Problems that Create Backlog

In the previous section, two factors that affect efficiency were noted: improperly completed DD Forms 1348's, and finding information for obsolete or untagged items that promotes excess time spent researching item's information. One other issue the researcher observed during the visit to DS at Camp Pendleton is that the facility receives more items than they can process in one day. The backlog accumulates due to the number of issues such as cross-dock trucks that arrive each day, customers arrive with unscheduled appointments exceeding demand for the day and the demand of items for disposal exceed the facility's capacity to process items.

A cross-dock truck acceptance is property from another DLA DS site. The other site does not have the capability to process items due to its limited authority to coordinate with contractors or because it processes only certain types of items, thereby transferring, or cross docking, it to DS at Camp Pendleton. Items outside its scope are delivered to bigger facilities that have greater authority to dispose of items. Nevertheless, on a daily basis, the Camp Pendleton site accepts ten trucks from local customers and an average of three cross-dock trucks from other sites. Each truck is assigned an RCN that tracks the number of days it takes to process the pallets and the estimated number of LIs in them. This observation was confirmed with the data provided by the area manager.

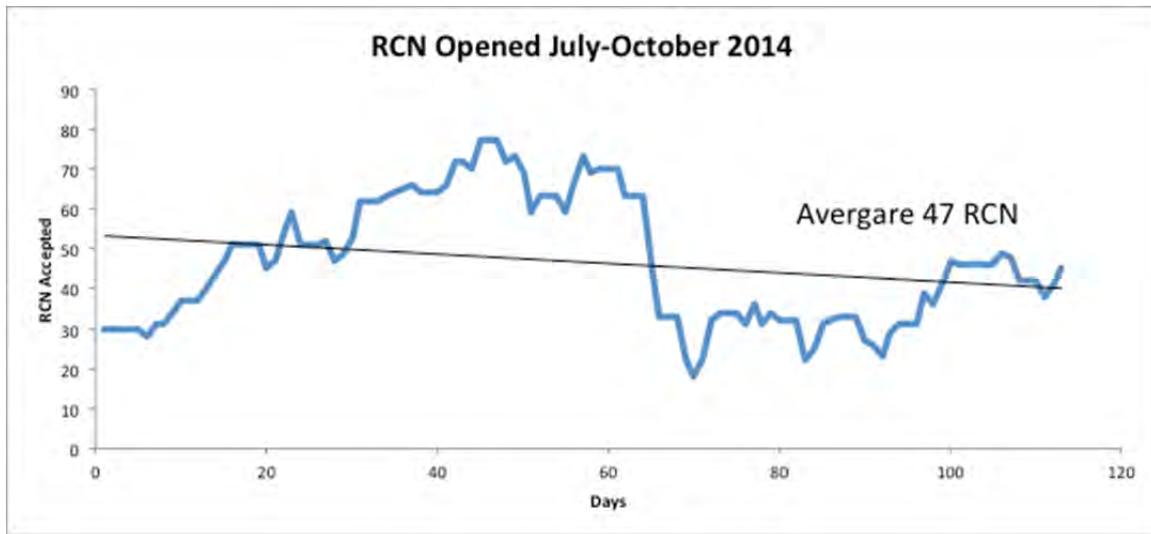


Figure 16. DLA DS at Camp Pendleton Average RCN (July to October)

Additionally, RCN become a nuisance such that the FTE may underestimate how many items are in the RCN. According to the SOP, the FTE estimates the amount of LIs prior to stowing the items in the backlog area:

A Receipt Control Number (RCN) is an eight character alpha/numeric sequence which indicates the Calendar year, month, day, and the number of turn-ins that is manually generated via Distribution Standard System (DSS). The RCN is created when a conveyance is received on site prior to the receipt process of Disposal Turn In Documents (DTID). The RCN provides workload visibility by identifying estimated line items received from individual turn-in customers, a pallet count, and a date and time the property was accepted. The sum of all active RCN line counts will determine and report Disposition Sites estimated unprocessed receipts. (DLA DS, 2013a, p. 1)

The RCN is the first control number tagged to the pallets in each truck conveyance however a pallet does not have a limit on how many LIs it is required to contain. One pallet could have one big bulky item, or it has an average four line items. The data shows that an RCN has an average of 13 pallets resulting in an average of 50 items per RCN. On average the DS at Camp Pendleton can process about 300 items per day with the current staff capacity, and on average the facility received 8.5 RCN per day resulting about 425 items to be processed per day. This study covered almost a four-month period, and during that time there were on average 2,259 items that accounted for about 47 RCN or 7.5 day's

worth of backlog that was in the backlog stowage area, suggesting that each RCN had almost 50 LI, as depicted in Figure 16. Therefore, the remaining items that are not processed daily go to the backlog for future processing. The coefficients are explained with the formula:

$$125 \text{ average daily of items for the backlog stowage area} = 425 - 300$$

At the beginning of the period of study the oldest RCN was 30 days old and at the end of the study period, was 45 days. This suggests that the ongoing demand surpasses capacity to process items for disposal. The logic of ongoing demand exceeds the process is because the items continuously arrive so items that arrive are processed plus the items in the backlog, the ongoing issue mitigates to reduce the backlog. However, if the crew proposes only items from the backlog without receiving any RCN it would take about 7.5 days. Calculated by 2,256 average items in backlog / 309 average items DS at Camp Pendleton can process as day.

At the beginning of July, the facility started with 1,082 line items in backlog. By the end of July, the facility ended with 3,072 LIs in backlog and accepted a daily average of 313 items. How did it triple? The disparity is noticeable in the first 7 days of July. On July 1–3, the facility accepted about 14 RCN's and the backlog doubled, from 1,082 to 2,320, suggesting that each RCN had an average of 51 LIs. Additionally, the staff could only completely process about 600 items in the 2-day period, so the remainder that was not processed was kept in the backlog. This scenario is ongoing through the days and months so the backlog does not reduce to zero, as illustrated in Figure 17. Furthermore, for the month of July an upward trend illustrates demand exceeded than the amount of items that were processed.

However, accepting LIs is not the only task in the focus of effort. The warehouse duties include storing, inventory, shipping, customer pick-up, rearrangement of backlog, cleaning, and scrap management. In addition, the site provides property disposal classes to all local units and accepts the property from four other cross-dock sites for processing. Considering all these factors suggests a growing problem that has potential leading bottleneck, backlogs, and increased disposition time.

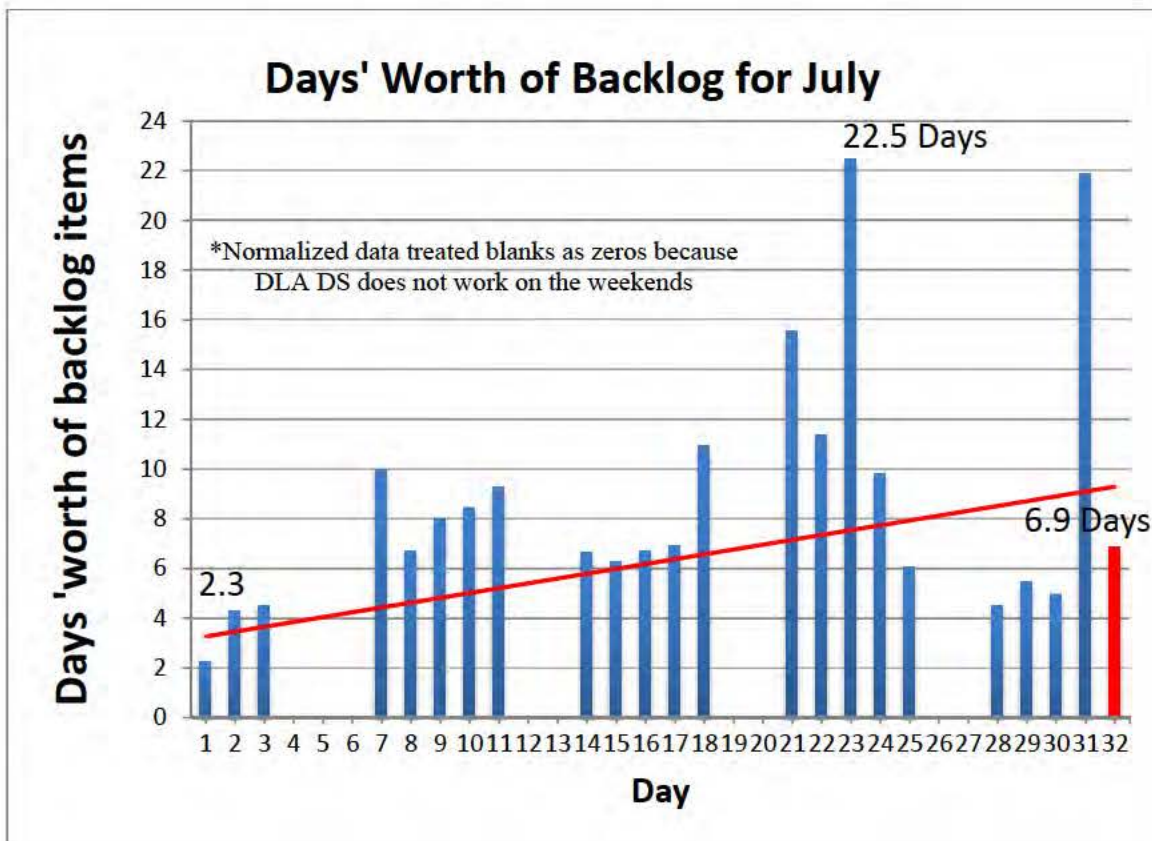


Figure 17. DLA DS at Camp Pendleton Day's Worth of Backlog Items for July 2014

Figure 17 depicts all DS working days for days' worth of backlog items for July. The calculation is the result of using the backlog ratio formula such that the calculation for 1 July and so on is the result from this computation:

$$2.3 \text{ days' worth of backlog items} = (1082 \text{ backlog items} / 486 \text{ items processed on 1 July})$$

The backlog ratio steadily grows throughout the month of July, reaching an average of 6.9 days' worth of items in the backlog for the month, depicted in red above number 32. Equally, day 23 is a day of concern because it reached over 22.5 days' worth of working items from the backlog stowage area, suggesting that a double amount of items were received compared to the previous day. Nonetheless, for the four-month period, the trend is downward, as illustrated in Figure 18, resulting in an average of 7.5 day's worth of backlog items. Arguably, this numbers suggest a backlog of days worth of

items for proper disposition is ongoing and management needs to find a solution to reduce it and eliminate backlogs.

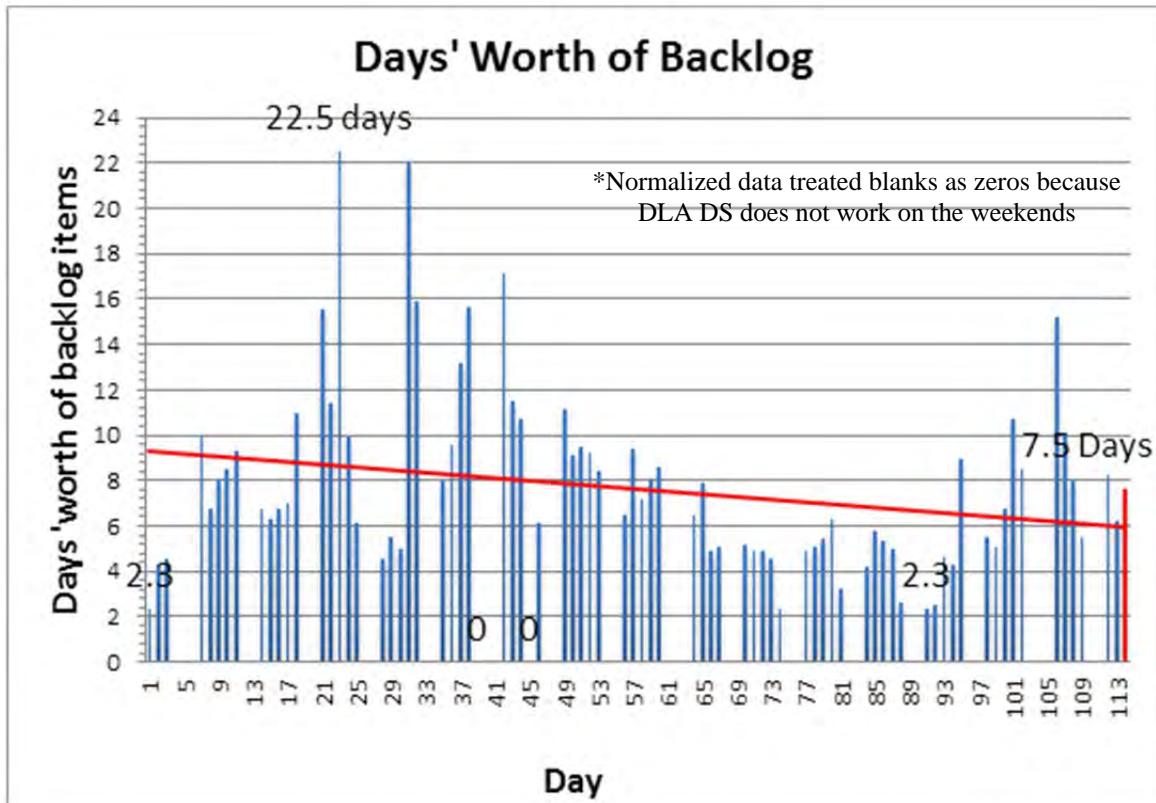


Figure 18. DLA DS at Camp Pendleton Day's Worth of Backlog Items from July to October 2014

Inverse trend relationship between processed versus backlog items. The data shows a trend that showcases underlying indicators of an inverse effect that an increase of backlogged items results in the decrease of processed items and vice versa. The trend is observed when at the beginning of the week more items are accepted affecting items processed to fewer numbers. Conversely, fewer items are accepted thus creating less backlog and more items are processed thus increasing the amount of processed items. This inverse relationship is clearly depicted in Figure 19, suggesting that in order to reduce the backlog fewer items must be accepted or productivity must be increased to equal out both components. Additionally, the backlog ratio compared to the number of

items processed is almost triple, indicating that DS at Camp Pendleton cannot keep up with more demand than what they can process. DS's property acceptance process is not enabled with technology and automation, so it does not deliver efficient or effective outcomes when benchmarked with comparable commercial practices.

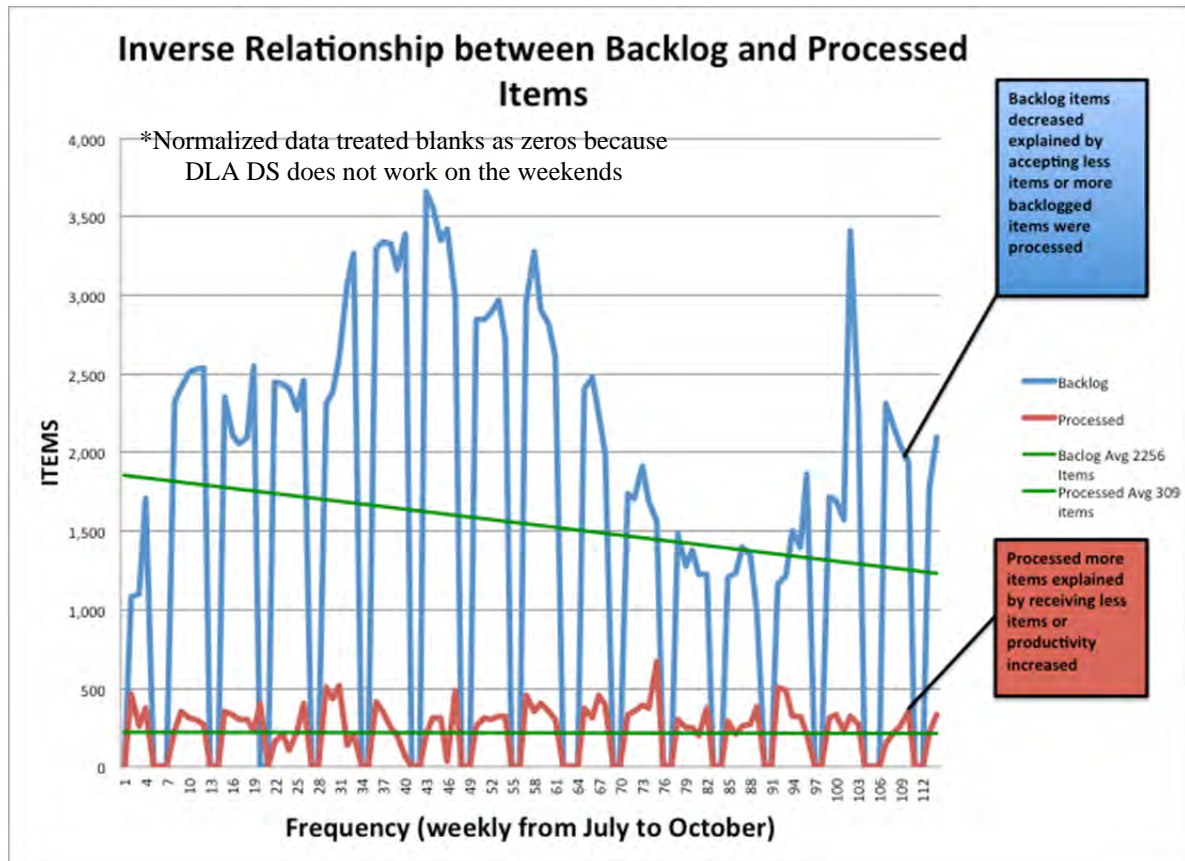


Figure 19. DLA DS at Camp Pendleton Inverse Relationship Pattern between Backlog and Processed Items from July to October 2014



Figure 20. Two Military Tents with Backlog Items
Note. The pictures were taken by the researcher in DLA DS at Camp Pendleton, California, in July 2014

Figure 20 shows two pictures of two dome tents outside the warehouse at DLA DS, Camp Pendleton. When the picture was taken there were about 47 RCNs with an estimated 2,313 items that accounted for about 7.5-backlog ratio in days' worth of items that are awaiting disposal.

c. Analyzing Backlog using Analytical Model to Resolve Backlog

A backlog of items that are waiting for future processing is a phenomenon created by unprocessed items that have been received but are not processed or are in the process of being completed because the number of items arrival exceed the employees' capacity to process. Unpredictability of items arrival and variability of service processing time leads to backlog or queues. Understanding and learning the queuing is an important area in operations management (Jacobs & Chase, 2010). For DLA DS at Camp Pendleton, item-processing demand vary by the amount of items processed per employee and often the amount of items exceeds normal capacity that the six-crew employee at Camp Pendleton can handle. However, the arrival of items can be controlled in a variety of ways. For example, DLA DS can reduce the amount of appointments per day, thereby

reducing the amount of items accepted, they can limit the number of items per pallet so that they only receive about 300 items per day, or extend the hours employees work but only process items in the queue and not accept more items during the extended hours. For the employees, DLA DS can affect service time by adding more employees, or implement machines to automate the process flow to increase productivity.

According to Jacobs and Chase (2010), the queuing system consists of three components: (1) the source of items and the way items arrive, (2) the servicing system such as servers or employees, and (3) the condition the items exit the system (p. 40). By calculating the three queuing components one can formulate the number of employees DLA DS at Camp Pendleton are needed to reduce and prevent days' worth of backlog. Therefore, to formulate the amount of employees are needed at DLA DS the coefficients in the following formula were utilized in a spreadsheet, Figure 21, designed to compute the characteristics of employees in the multiple-server queuing model using arrival rate of items and service rates each employee processes.

The queuing model illustrated in Figure 21 used results from previous section with regard to averages of items received at DLA DS at Camp Pendleton, California, average processed items per employee per hour, and number of employees in the items disposal crew at DLA DS Camp Pendleton, California. That means that on a daily basis the Camp Pendleton facility received an average of 425 items for disposal; therefore per hour they accepted about 65 items per hour and an employee can process 7.5 items, suggested by the DLA DS study (2013) and the Camp Pendleton facility (2014) had a six-employee crew for item disposal during the period of the study.

Analysis: Number of Employee Required at DLA DS, Camp Pendleton, CA		
Assumptions: Multiple servers, Infinite population, Poisson arrival, Exponential service time, Unlimited waiting warehouse size		
Yellow cells need user inputted values		
Inputs		Coefficient unit:
Unit of time	Hour	
Arrival rate (lambda)	65.38461538	Items per hour
Service rate (mu)	7.5	Items per hour
Number of identical employees (server [s])	9	Employees
Outputs		Coefficient unit:
Direct outputs from inputs		
Mean time between arrivals	0.015	Hour
Mean time per service	0.13	Hour
Traffic intensity	0.968660969	Capacity
Summary measures		Notes:
Average utilization rate of server	96.9%	Capacity
Average number of items waiting in backlog (Lq)	27.64978	Items
Average number of items in system (L)	36.36773	Items
Average time waiting in line (Wq)	0.42288	Hour
Average time in system (W)	0.55621	Hour
Probability of no customers in system (P0)	0.00003	Probability of empty system
Probability that all servers are busy	89.5%	Percentage of items that wait in backlog
Probability that at least one server is idle	10.5%	Percentage of items that don't wait in backlog

Figure 21. Spreadsheet of Analysis the Number of Employees Required at DLA DS in Camp Pendleton, California

Figure 21 is an Excel template for using analysis with the queuing model to choose the number of employees for DLA DS at Camp Pendleton, California. The spreadsheet was designed to compute characteristics of multiple employees, using the average arrival rate of items per hour, and service rate each employee can process per hour. The output coefficients are the mean time of items arrival at per hour during an expected 6.5-hour working per day, and the mean time items processed for a crew of employees per hour during an expected 6.5-hour per day.

Table 4 illustrates the results from the queuing model with changing employees from six up to ten. With eight employees one can see significant improvement to the

probability to decrease backlog from 255% to 135%. Adding the ninth employee provides a 97% capacity meaning that the facility can keep up with demand by processing all received items and have a 3% idle of down time, which will be initially used to reduce the 7.5 days' worth of backlog. Therefore, with nine employees the facility provides a 97% capacity in term of processing items upon arrival to mitigate backlog in the future. On average DLA DS received 425 items a day and with a crew of six the DLA DS at Camp Pendleton processed about 300 items; thus, on a daily basis about 125 items are placed in the backlog to process them on the first-in first-out basis. The facility had 7.5 days' worth of backlogs; therefore with nine employees the facility will slowly reduce the backlog and be at capacity with relations to items arrival, because the facility will be able to process 450 items per day and about 425 items are accepted.

Table 4. Sensitivity Analysis of Number of Employees to Reduce Backlog

Sensitivity Analysis: Number of Employee Required at DLA DS, Camp Pendleton, CA			
Employee (s)	Facility Capacity	Percent Items in Backlog	Percent Items not in Backlog
6	145%	255%	-
7	125%	185%	-
8	109%	131%	-
9	97%	90%	10%
10	87%	59%	41%

d. Summary

The process flow is very lengthy, and DLA DS needs to manage it in an average of 42 days in order to provide an opportunity to RTD items to branches of service, federal agency, or local agency. DLA DS needs reduce backlogs, increase efficiency and take advantage of opportunities. As seen in this analysis, there are steps in the process flow that have potential to create a bottleneck. This section examined the three steps in the items process that are areas of concern. The results show that there are four areas of concern that contribute to creating days' worth of backlog items. First, improperly filled DD 1348 provides for additional time to spend conducting research in order to fill the DD

1348 for further processing. Second, verifiers spend time to conduct research on items that are not labeled or documented on a DD 1348. About less than 1% of accepted items are unlabeled. However, the 1% of unlabeled items is not the main problem of days' worth of backlog items, the third problem can be safely argued that DLA DS at Camp Pendleton accepts more items than what it processes, resulting in an average over 2000 items in the backlog stowage area. DLA DS at Camp Pendleton is limited to processing about 300 items per day but it received an average 425 per day in an average of 8.5 RCNs per day, leaving the remainder to add to the backlog; therefore, the demand exceeded the amount of items that were processed. Similarly, fourth, RCNs are not limited to the amount of items that will fit in a pallet or tri-box, such that an RCN can have about 50 items. The results from the queuing theory suggests that, with nine employees, the DLA DS at Camp Pendleton will keep up with demand by processing all received items and have a 3% idle time, which will be utilized to reduce the 7.5 days' worth of backlog.

DLA DS made progress in reducing the lead-time on the process flow by implementing the Lean Six Sigma in 2008; however, additional changes need to be created in order to improve the lead-time. In general, these challenges are corrected with adequate automated processes and the focus of this study is addressing inefficiency to correct it with the implementation of technology. With that in mind, the next section assesses object/shape recognition technology COTS sectors.

B. ASSESSMENT OF OBJECT/SHAPE RECOGNITION TECHNOLOGY MATURITY

1. Overview

The Technology Readiness Assessment (TRA) is designed to allow program managers, acquisitions personnel, and decision-makers to understand the risk, cost, and time associated with maturing technologies. This section of this study reports the results of the assessment results of three different companies' object/shape recognition technology. The three companies of interest are listed in Figure 22 with each company's description. The assessment follows the Department of Defense Technology Readiness Assessment Guidance (ASD[R&E], 2011), and for the purpose of this study the

researcher adopted and customized the Department of Energy's (2012) template for assessment to make it suitable for assessing object/shape recognition technology systems. The assessment consists of separate reports for each companies' technology that include (1) an overview of the company's object/shape recognition technology profile; (2) technology's goal; (3) benefits; (4) critical area(s) of challenge; (5) qualitative summary of the TRL; and (6) a statement of relevancy to DLA DS. Finally, the section concludes with a summary of the strengths and weaknesses of object/shape recognition technology.

Object Shape Recognition Companies and their Programs



Cognex delivers the widest range of image-based factory automation and distribution products to help companies like you ensure error-free production, lower costs, and manage your supply chain:

Barcode readers to ensure part and product traceability

Vision systems and software for quality inspection and automation

Vision sensors to detect part features and verify assembly

Laser profilers and software for 3D inspection to further optimize quality

Source: www.cognex.com



When business leaders and innovators like you engage with Imaginestics and discover the VizSeek® shape-search engine, their first question is often: "Can it do this?" Instinctively, the answer is always, "Yes."

The VizSpace supply-chain sourcing network and the evolution of clientele licensing our shape-search technology are all prime examples of true American ingenuity. If you can envision a function for shape search, inside the VizSpace network or out, the Imaginestics development team is available to partner with you and engineer a new application that meets your group's unique requirements.

We have a creative, technically innovative team adept at taking your imagined solution and making it a reality. The possibilities for shape search are limitless – from determining cost to configuring products. Get in touch with us and give us your idea. The possibilities are limitless!

Source: www.imaginestics.com



Augmented Reality

RMD is developing a revolutionary training and enabling technology based on augmented reality. It is extremely valuable for speeding training and repairs, detecting and preventing errors, saving money and time, and improving safety.

Source: www.rmdinc.com

Figure 22. Three Companies with Recognition Technology Programs

2. Cognex

Overview: Cognex's technology is a belt-driven single file carousel that identifies items by scanning bar code tags. The items are associated with a database mainly by using the serial numbers on the item's tag. Cognex manufactures the hardware like the image capture devices and they partner up with companies that offer integrated solutions to connect Cognex hardware. However, for large multi-million-dollar project Cognex offers direct integration to innovate a system. Consequently, Cognex does not have a prototype application to qualify for DLA DS requirement, but its current concept of processing items is applicable to DLA DS.

Cognex Technology's Goal: Currently, Cognex's technology is used in companies where specific item precision is required. For example Cognex technology detects defects with sensors, 3-dimensional (3D) lasers, scanners and cameras in order to improve production productivity at a higher speed.

Benefits: The technology's approach is to provide efficiency and effectively manufacture or inventory items. The industries that benefit from Cognex technology are automotive, food and beverage, and electronics as depicted in Figure 23. With regard to DLA DS, Cognex's concept that can be applicable currently is not in a COTS form that DLA DS can plug and start to operate.

Critical Area of Challenge: Critical technology challenges related to meeting DLA DS requirements include the fact that the Cognex machines are specific to a company's design and needs, so a prototype to fit DLA DS needs will need to be reengineered from the ground up. What this means is that operational equipment intended to identify an object without bar codes technique is not available at Cognex. However, Cognex has the technology and partners to conduct R&D in order to custom make a technology for DLA DS.

Qualitative Summary of Cognex's Technology (TRL): A technology that is ready with DS' specification and to be operated at DS facility or similar environment has not been created. Clearly, Cognex will be required to engineer and integrate elements from partners that would require technology maturation; therefore, Cognex's technology

values in the TRL scale 2 (see Table 5 for the TRL definition). Currently, Cognex has made machines that operate at specific owners requirement, so they have the concept and principle formulated relevant to DLA DS requirement. However, technology for DLA DS would be considered to be in a limited paper study such that its current system would be left for speculation to be applicable as it is; therefore, further maturation would be required under an investment program and contract.

Table 5. Description of Technology Readiness Level 2 (from USAF, 2010)

TRL	Definition	Description
2	Technology Concept and/or Application Formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples remain limited to paper studies.

Statement of Relevancy to DLA DS: Cognex explicitly described that a project of large scale, such as full automation with carousel belts, scanners, and image capture devices, would be worth pursuing. Meanwhile, a small project, such as a mobile device with image capture apparatus, would be an undertaking for one of Cognex’s partners and eventually Cognex would mature it to a grand scale.

Figure 23 illustrates Cognex technology that is designed to scan and read bar codes while the items move on a carousel system. Similarly, the laser and scanner can detect anomalies and read codes and discrepancies with items specifications.



Figure 23. Cognex Product Identification Machines
Note. Picture from Cognex Pamphlet and Cognex YouTube video

Figure 24 illustrates a large-scale supply chain logistics warehouse operated with Cognex technology. The technologies included are scanners, and laser and image capture devices to efficiently and effectively control inbound and outbound inventory.

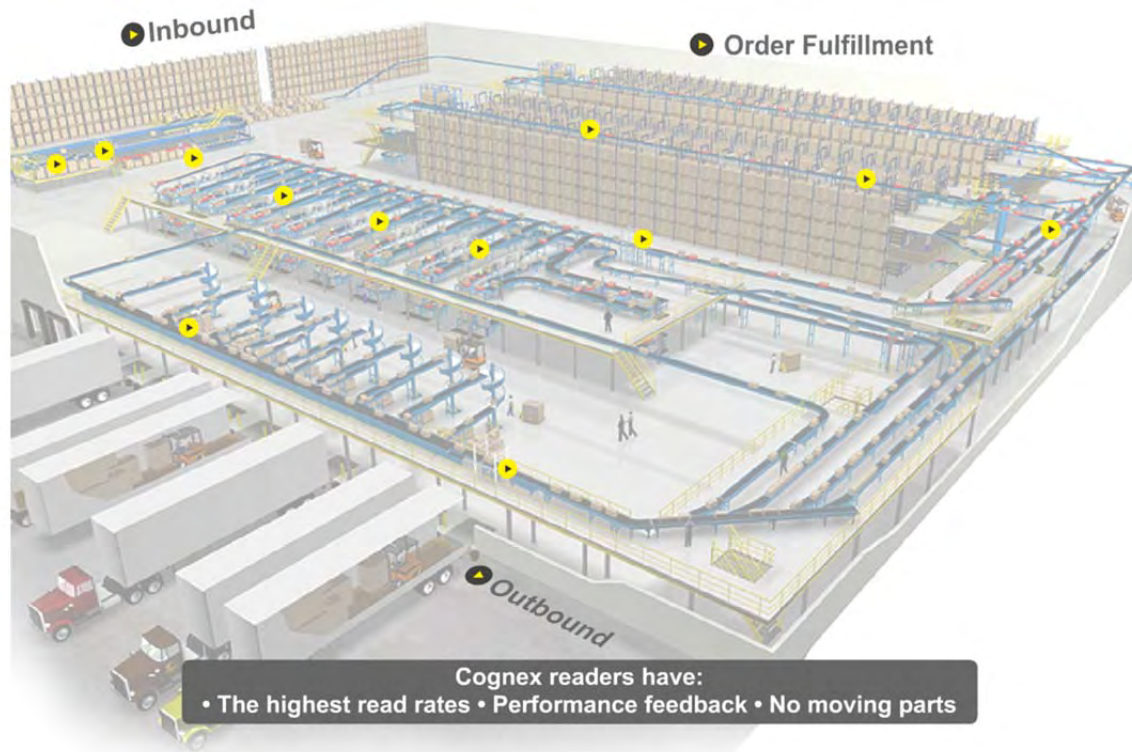


Figure 24. Cognex Large Scale Machines (from Product Cognex, n.d.)

3. Imaginestics

Overview: Imaginestics has developed a technology that is an application for mobile devices, which includes phones and tablets for both Apple and Android operating systems. The technology is designed to find shapes and objects that are similar to a given visual input, labeled by Imaginestics Smart Shape Technology and trademarked as VizSeek®. A picture captured by the mobile device is used to search shapes in a VizSeek® database. The image's shape is associated with an indexed database to provide feedback. The mobile device conducts the search on VizSeek® which requires either Internet or an intranet (behind the firewall) to access the database. To create the indexed database, VizSeek® extracts and archived shapes and text from images, documents, and other sources of database. Imaginestics main contribution to the shape recognition technology is to extract the information by normalizing the data so that information is indexed from the content, such as diagrams and images from manuals, publications, and so forth. Imaginestics technology is capable of searching images from two and three-

dimensional models (see Figures 15 and 16). This means that it recognizes the image from any angle and format rather than recognizing an image to an image. Imaginestics was a winner of the Indiana Entrepreneurship Award. The merit of the award is outstanding, but what is of importance to this assessment is the fact that the DOD funded the research, so Imaginestics understands the DOD acquisitions process. The award citation states the following:

Imaginestics' vision is to organize and market industrial manufacturer's product and service information and make it visually searchable and useful worldwide. As the first step in making industrial manufacturer's product and service information visually searchable...developing 2D shape matching technology and unique intranet search engine... [and]... developing the 3D shape search algorithm at Purdue University. [Then]... developed VizSeek, the world's first online visual search engine for manufacturing. In addition, they also worked on value added solutions such as VizAdvise, VizCompare and VizConfig to make the search results obtained useful for the search user. Imaginestics received funding support from National Science Foundation, Department of Defense and Indiana Economic Development Corp. to conduct research and development of these solutions. ("Indiana Entrepreneurial Leadership Awards Winners," n.d.)

Imaginestics Technology's Goal: Imaginestics' technology is used to organized information such as shapes of objects so that it is searchable using a mobile device and feedback with the images' information is provided in seconds under the condition that the database has the information indexed.

Benefits: The technology's approach is to provide information from an image. The industries that benefit from Imaginestics' technology are aviation and supply chain management. Currently, Lockheed Martin uses the technology to conduct research and make costing estimates. With regard to DLA DS, Imaginestics' technology is applicable. As a COTS technology DLA DS will require further maturation to be applicable to DLA DS requirement. For example Imaginestics is capable of indexing information from converted images in optical character recognition (OCR) format such as printed manual in order to digitized it and index it in the VizSeek® database. This modification will require the buildup of a database specifically for DLA DS. Another benefit from Imaginestics is that the mobile device that captures the image can be used to

consequently upload the same picture in DLA DS liquidation website to resale the items rather than contracting a photographer.

Critical Area of Challenge: Critical technology challenges related to meeting DLA DS requirements include the fact that a database will have to be built. Additionally, because the system operates via the Internet and Apple Inc. devices the challenge relates to getting approval from the Defense Information System Agency (DISA) with respect to information assurance (IA) credentials. However, the credibility package is part of the acquisitions process.

Qualitative Summary of Imaginestics' Technology (TRL): Imaginestics technology is the closest technology that is ready with DS specification and to be operated at a DS facility, however it has not been operated in a DS similar environment under DISA IA requirements. Imaginestics' shape recognition technology is being utilized by Lockheed Martin, so technology components relevant to DLA DS requirement is known to work. However, the database aspect of the technology will be required to be engineered and to integrate elements from the current prototype, which would require maturation; therefore, Imaginestics' technology values in the TRL scale between 4 and 5 (see Table 6 for the TRL definitions). Currently, Imaginestics has made machines that operate at specific owner's requirement, so it has the concept, principle, and prototype formulated relevant to DLA DS requirement. The system hardware and software integration has progressed beyond the laboratory phase.

Table 6. Description of Technology Readiness Levels 4 and 5
(from USAF, 2010)

TRL	Definition	Description
4	Component and/or Breadboard Validated in Laboratory Environment	Basic technological components are integrated to establish the feasibility that the pieces will work together. This is relatively low fidelity compared to the eventual system. Examples include integration of ad hoc hardware in a laboratory.
5	Component and/or Breadboard Validated in Relevant Environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include high-fidelity laboratory integration of components.

Statement of Relevancy to DLA DS: Imaginestics has been approved for IA approval for another technology that is contracted under the Navy and Office of the Secretary of Defense (OSD); therefore Imaginestics understands the DOD acquisitions processes and IA approval request process.

Figures 25 and 26 illustrate the search and results of a compressor, respectively. The image of the compressor in Figure 25 was matched with an image of a compressor from government liquidation website. The results illustrated in Figure 26 is the interface from VizSeek® depicting the feedback information of the compressor, such as the cost, NSN, DMIL code and DTID number related to the order tracking number entered by DLA DS when the compressor was processed for resale.

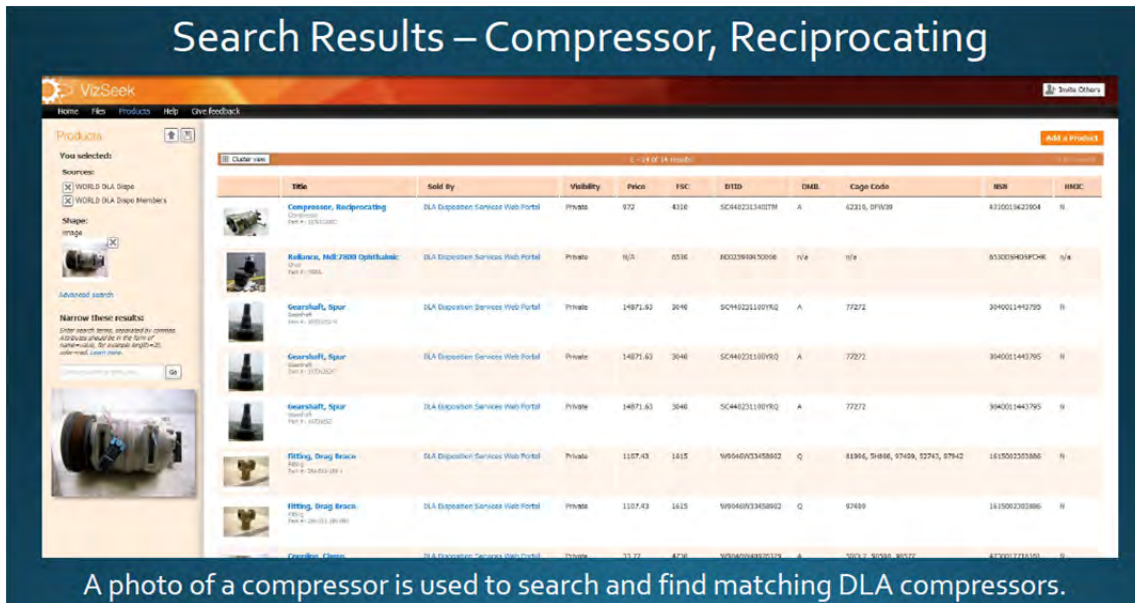


Figure 25. VizSeek® Application Matches Compressor Image with Database



Figure 26. VizSeek® Results with Image and Pertinent Information

4. RMD

Overview: RMD created a technology, called the automated digital recognition technology (ADIRT), which is focused on the artificial intelligence perspective. The technology is designed to capture images but the user verifies the information the first time the image is introduced to the ADIRT. The subsequent time when the image is presented ADIRT automatically recognizes it to processes it for identification and provides feedback. RMD built a prototype for the Marine Corps. The Marine Corps initially funded the R&D; however, under the budgetary cuts the program was no longer funded. Consequently, RMD has not matured the technology any further; however, RMD's technology qualifies within the DLA DS requirement. RMD's technology concept of processing items is applicable to DLA DS, but requires further funding for maturation. RMD estimates a two-year period to provide a prototype to DLA DS.

RMD Technology's Goal: ADIRT under its current state was designed to support electronic technicians to automatically recognize a circuit board retrieving schematics for repairs. ADIRT uses a laser projector to point at the part in the circuit board so the mechanic conducts the repairs to the component in the circuit board. This enables the technician to identify and locate unlabeled components and part numbers easily, correlate them with documentation, and communicate with databases across platforms and organizations (RMD, 2014).

Benefits: The technology's approach is to capture knowledge in the form of artificial intelligence so that any technician uses the technology to guide them when repairing the circuit board. The Marine Corps concept was to retain in a database the knowledge of well-training electronic technician and pass on the knowledge to any junior Marine. Given that ADIRT is designed to remember procedure in accordance with technical manuals, when the technician fixes a circuit board, ADIRT provides the potential to capture any knowledge to turnover for continuity.

Critical Area of Challenge: Critical technology challenges related to meeting DLA DS requirements include the fact that the initial prototype was built for a different purpose. Additionally because the system operates via the Internet and has the capability

to operate in a mobile device, the challenge relates to getting approval from the DISA with respect to IA credentials. However, the credibility package is part to acquisitions process. Additionally the current prototype is not in a mobile device state. The current prototype is a computer with a camera and laser projector, so the challenge is to reduce the size to a mobile device, which calls for further maturation.

Qualitative Summary of RMD's Technology (TRL): RMD will be required to engineering and integrating elements from its current prototype, ADIRT, which would require further R&D for the technology to mature; therefore, RDM's technology values in the TRL scale 2 (see Table 7 for the TRL definition). Currently, RDM has made a prototype that operated for the Marine Corps requirement of training technicians to conduct repairs, and the technology detects and prevents errors. RMD has the concept and principle formulated relevant to the DLA DS requirement. However, to make RMD's technology fully relevant to DLA DS, the technology is considered to be in a limited paper study such that RMD current system is beyond speculation to be applicable as it is; therefore, further maturation would be required under an investment program and contract.

Table 7. Description of Technology Readiness Levels 2
(from USAF, 2010)

TRL	Definition	Description
2	Technology Concept and/or Application Formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples remain limited to paper studies.

Statement of Relevancy to DLA DS: RMD explicitly explained that the technology was designed for mechanical maintenance rather than for supply-chain management. According to RMD it will

deliver a prototype to DLA in the tenth month of year one for testing at their facilities. In year two of the program, RMD will deliver a more

advanced prototype in month 22 of the 24-month program for test and validation at the DLA” (RMD, 2014).

Therefore, RDM’s technology is not ready for the near future and would required excess funding to mature it.

Figure 27 illustrates RMD’s technology that is designed to scan and read schematics while the technician makes repairs to the circuit board. The laser projector is designed to pinpoint which component on the circuit board to repair. The technology is designed to learn the process the first time it is introduced with a circuit board. The subsequent time when the same-type of circuit board it repaired the system navigates the technician to conducts the repair to the component as previously conducted.



Figure 27. RMD Product Identification Machines (picture from rmdinc.com)

5. Strengths and Weakness of Object/Shape Recognition Technology

The root causes for automating a company with technology is to cut costs, target inefficiency, and control breakdowns in managing inventory, and capture data for

analytics purpose. Technology presents strength and weakness, including strengths with standardization, productivity, inventory control, and management. Conversely, technology presents weaknesses with upfront capital investment, reliance on the information and information assurance, and equipment fragility.

a. Strengths

1. Standardization—technology ensures uniformity and conformation across the board.
2. Productivity— technology can reduce time in identifying items, thereby increasing productivity.
3. Benefit—the benefits will outweigh the initial investment cost, in the long run, usually after the payback period then benefit grows by providing time and labor saving earnings.
4. Accuracy—error is marginal, when proper information is indexed to return correct feedback. A database program provides the ability to conduct data mining for analytics. Analytics improves operational efficiency by facilitating effectiveness of processing items.
5. Operate—ease of operation with minimal training.

b. Weaknesses

1. Cost—initial upfront investment cost and maintenance cost. Additionally, technology has a double-edged sword, such that favorable benefits are gained upon the recovery of the funds expended. However, the technology depreciates and wears to the point of affecting its performance—ultimately becoming inoperable. Therefore, replacing it adds another round of cost.
2. Feedback—reliance on information keyed in the database. In other words, the feedback accuracy relies on the manually entered information in the database, unless it is an artificial intelligence that is adaptive and self-learning. Nonetheless, the feedback could be unreliable due to incorrect data in the database. The trend is counteracted if the wrong information is entered where the focus should be elsewhere.
3. Fragile—environmental conditions or accidental mishaps may break the equipment.

C. CHAPTER SUMMARY

This chapter presented the examination of the data and item process from DLA DS at Camp Pendleton, California, as well as an assessment of three companies' object/shape recognition technology. Based on the analysis of item process, the data suggests and emphasizes that there are four areas of concern that drive inefficiency and backlog. Improperly filled DD 1348 added time to the items disposal process due to researching the item's information; RCN's items are limitless and backlogs are created due to accepting greater items than it can be processed qualify for factors that require a solution and portrays the importance of this study.

Despite previous changes to streamline the steps, the current process can be further improved to reduce or eliminate backlogs. Generally, automation through use of technology generates favorable conditions that can be considered for implementation. Currently, the private and government sectors have some form of object/shape recognition technology to support their missions. Of the three companies' technologies that were assessed under the TRA guidance, Imaginestics technology is the most viable and mature system, ranking up to a TRL 5. However, the standard dictates that only a TRL 7 or above is mature, and therefore, can be considered for implementation. Imaginestics technology has the potential to be a quickly working model and ready for implementation with less considerable time and cost, compared to the other two technologies analyzed here. An object/shape recognition tool offers benefits, such as reducing property identification time, when a well-designed infrastructure is in place. However, consideration of upfront cost must be analyzed to justify the investment and determine whether it will be sustainable in the long run. The focus of Chapter V is the CBA that presents financial aspect of investing in object/shape recognition technology.

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V. COST-BENEFIT ANALYSIS

The objective of this chapter is to examine whether the expected benefits of implementing object/shape recognition technology justify the cost. The analysis generates a measure of the expected economic return on investment, and evaluates the feasibility that object/shape recognition technology can be installed at DLA DS at Camp Pendleton. The CBA is consistent with the U.S. government guidance: Circular A-94 *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (OMB, 1992), and DOD Directive 5000.2 Interim—supportability analysis (DOD, 2013a). The benefits are estimated as cost-savings from reduction in time to dispose items resulted from implementing object/shape recognition technology to the item disposal process.

This CBA analysis evaluates two competing alternatives: the status quo, which is labor intensive, and the option of investing in object/shape recognition technology for the purpose of replacing the status quo. This study is an ex ante CBA-type conducted prior to the project in order to show whether it is worth investing in object/shape recognition technology and to provide information to DLA DS decision-maker prior to making the investment. Notwithstanding, there are nine basic steps in conducting a CBA, described as follows:

Step 1: *Specify the set of alternative projects.* DLA DS currently operates the property process without technology; therefore, this alternate is considered status quo and maintains DLA DS property identification in its current state. The second alternate will be evaluates and analyzes operations with technology.

Step 2: *Decide whose benefits and costs count (standing).* The stakeholders are identified as follow: DLA DS decision-makers consider the cost and the benefit of the alternatives. DLA DS employees are directly impacted by the decisions because they conduct the property identification process. The U.S. Congress mandated that DLA DS to cut operating costs, and taxpayers continue to fund the U.S. government through taxes. This thesis focuses on providing information to DAL DS decision-maker.

Step 3: *Catalog the impacts and select measurement indicators.* The analysis result includes input of time in units and cost of labor. Comparably, the focus is then shifted to associate cost of labor with and without technology in order to measure cause and affect outcomes. The results should provide benefit and cost impact.

Step 4 : *Predict the impacts quantitatively over the life of the project.* The time horizon is limited to 10 years to discount the cost of technology depreciation and replacement. There is uncertainty beyond the 10-year period, and to capturing that prediction is complex.

Step 5: *Monetize (attach dollar values to) all impacts.*

Time as a variable is monetized in order to provide the return on investment and to make the baseline for the “willingness to pay.” The researcher determined that investing in object/shape recognition technology would not incur revenues, and the investment is for only one facility, thereby not being a big acquisition program to raise revenues. The nature to justify the investment is costs saved. The DLA DS does not make revenues, given that it is part of the DOD; rather, the benefits is the money saved by reducing time task and increasing productivity. Therefore, the employees’ work-time is monetized and considered only when the particular employee uses the technology to reduce task time researching items, consequently increasing productivity.

The researcher calculated the annual wages for a GS-11 in dollars per hours in order to monetize the LSN research task, such that the assumption is that automating the identification process with technology will save money in labor cost. The Verifier at Camp Pendleton is a GS-11 whose annual wages is between \$50,790 and \$66,027 and spends half the day researching items’ information. Therefore, this study calculated the following information, as depicted in Table 8.

Table 8. The Annual Cost of Researching Items Is \$27,282

DLA DS Billet: GS 11 Pay		\$50,790.00 - \$66,027.00 / Per Year
For this study \$59,255 is utilized for calculations		
Description	Result	Formula
\$ per hour	\$28.49	59255 ann wgs /(8hr day * 5 days)*52wks
Mins spent on 17 items	221	13 min *17 items
Hrs per day spent researching	3.68	221 min/60 in hr
Cost per day	\$104.93	\$28.49 per hr * 3.68 hrs per day
Annual cost researching	\$27,281.99	(\$105 cost per day*5days) 52 wks

Table 8 illustrates calculations that result in \$27,282 a year to research items' information. The calculation accounts for a GS-11 Step 6 who dedicates almost four hours a day with items that need furthers steps to research information on one of three databases to properly dispose the items. The effect of the change in cost is variable due to the levels of GS with step wage an employee may hold. Furthermore, the scope of this thesis limits the amount of variables one can research and utilize for accounting how any other income from other variable may generates more market comparable revenues. However, the net present value (NPV) utilizes the final cost of \$27,282 as a form of benefits.

Step 6: *Discount benefits and costs to obtain present values.* This analysis took into account a 2.5% social discount for labor pay-raise increases. Additionally, a nominal discount rate is used to discount cost and benefit over the 10-year horizon time. Thus, in order to account for the time value money this research used a 7% discount rate. According to the Circular A-94, when analyzing proposed investment the 7% rate is ideal for calculating the return on investment in the private sector (OMB, 1994).

Step 7: *Compute the net present value of each alternative.* The NPV equals the present value of benefits minus the present value of costs:

$$NPV = PV (B) - PV(C)$$

Therefore, corresponding with the formula the cost of status quo is in the form of the opportunity cost, such that by leaving the item disposal process as is DLA DS misses

the opportunity to increase productivity; thus, the alternative with technology reaps the benefits in the form of money saved by reducing time task and increasing productivity.

Nevertheless, there were challenges of gathering actual technology cost posed by the companies' leadership, due to proprietary technology rights, privacy policies, and cautious in advertising actual cost without negotiating a contract. But discussions to estimate cost in a theoretical nature were provided by one company in order to conduct the thesis. Therefore, the minimum cost to buy object/shape recognition is about \$150,000 for one facility. This includes hardware, software, and licensing. The intent of the study is to offer decision-makers as possible related information to what the commercial sector has to offer on object/shape recognition technology; so under the circumstances this is the best estimate provided to conduct the study. Nonetheless, the steps and procedures are consistent with the guidance such that it can be used to further exploit the actual cost with an accurate quote.

In order to calculate the NPV, a Monte Carlo model was utilized. The model accounts for risk associated with future uncertainty of the 2.5% social discount for labor pay-raise increases, which may be approved by the U.S. government. Therefore, it turns out that the NPV for technology provides greater benefit than status quo.

Step 8: *Perform sensitivity analysis.* A sensitivity analysis supports the CBA by changing the wages as a form of revenues assumptions to understand risk factors that investing in object/shape recognition technology inherits. Table 9 illustrates wages a maximum or minimum in terms of revenues. To account for the uncertainty of the predicted impact, this study conducted a yearly variance sensitivity analysis using the 5% lower bound in the NPV's confidence interval that resulted with \$56,818 and the 90% upper bound NPV's confidence interval resulting in \$66,536. The minimum and maximum values for NPV are at \$53,732 and \$70,400, respectively. Thus, NPV remains positive with the variations in wages percentage increase or decrease. Appendix C illustrates the sensitivity analysis that supports the CBA by changing the wages social discount as a form of revenues from pay raise or cut between the time value money discount rate for assumptions in order to understand risk factors in investing in object/shape recognition technology inherit.

Table 9. Net Present Value Results

Data												
Initial Investment	\$ 150,000											
Cash Flow Year 1	\$ 27,282											
Growth rate 'g' (1% Std Dev)	2.50%											
Discount rate 'r'	7%											
Time (yrs)	10											
Fiscal Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
Year	0	1	2	3	4	5	6	7	8	9	10	
Growth		3.79%	2.28%	2.47%	4.03%	2.90%	1.61%	2.70%	4.56%	2.69%	3.78%	
Cash Flows (CF)	-\$ 150,000	\$ 27,282	\$ 27,904	\$ 28,594	\$ 29,747	\$ 30,608	\$ 31,102	\$ 31,941	\$ 33,397	\$ 34,294	\$ 35,591	
Discount CF FACTOR	1	0.93	0.87	0.82	0.76	0.71	0.67	0.62	0.58	0.54	0.51	
Discount cash Flow	-\$ 150,000	\$ 25,497	\$ 24,372	\$ 23,341	\$ 22,694	\$ 21,823	\$ 20,725	\$ 19,891	\$ 19,437	\$ 18,654	\$ 18,093	
Cumulative Discount CF	-\$ 150,000	-\$ 124,503	-\$ 100,131	-\$ 76,790	-\$ 54,096	-\$ 32,273	-\$ 11,548	\$ 8,343	\$ 27,780	\$ 46,434	\$ 64,527	
Net Present Value Results:												
NPV	\$ 64,527											
Internal Rate of Return (IRR)	15.13%											
Profitability Index (PI)	\$ 1.43											
Pay Back (years)	6.7											
NPV - Monte Carlo Simulation Results												
Number of Samples:	1000											
NPV Mean	\$ 62,265											
NPV - Standard Deviation	\$ 3,397											
Minimum	\$ 53,732											
Maximum	\$ 70,400											
5% Percentile	\$ 56,818											
90% Percentile	\$ 66,536											

Step 9: Make a recommendation.

The recommendation to implement object/shape recognition is viable; however it will solve the less than 1% of unlabeled items and not solve the 7.5 days' worth of backlog items for the DLA DS facility located in Camp Pendleton. The estimated cost to implement one object/shape recognition system is about \$150,000. The total quantified net economic benefit occurring from the technology's contributions is estimated to be about \$65,000 when applying a 7% discount rate, and a 2.5% social discount for labor pay-raise increases the corresponding internal rate of return results at 15.13% —making the investment desirable to pursue, and profitability index (PI) 1.43, indicating that for every dollar invested, \$1.43 in benefits is accrued with a payback period 6.7 years over a 10-year time span. Applying a 7% discount rate yields a NPV of \$35,591. The payback period is illustrated in Figure 28.

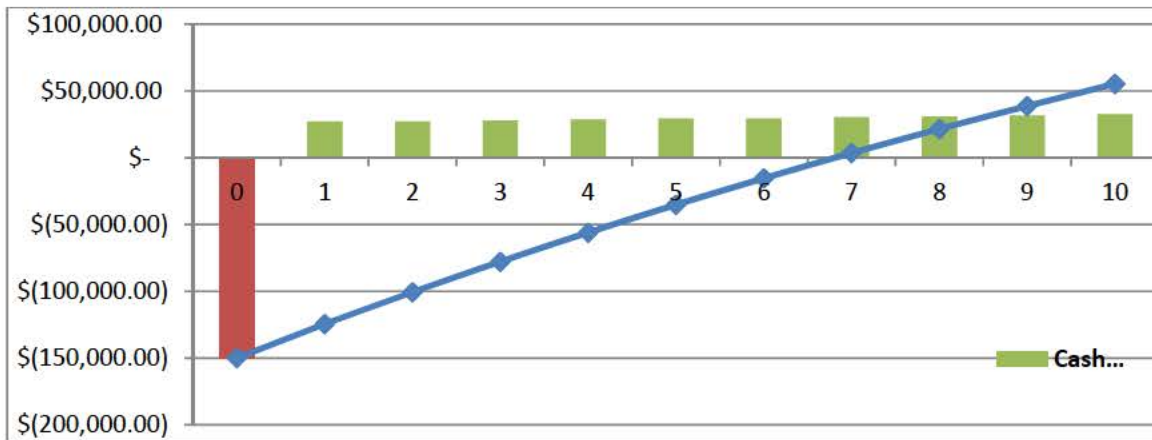


Figure 28. Payback with Money Saved by Reducing Task Time

A. SUMMARY

The benefit from implementing object/shape recognition technology outweighs the cost to purchase it. The new technology will save money in labor costs. The 10-year period of revenues provided by the technology recoups the \$150,000 initial investment in about seven years such that the internal rate of return of 15% is greater than the cost of capital estimated at 7%. The profitability index is \$0.43 to each one dollar invested, suggesting that DLA DS should execute the investment and pursue it for further maturation. However, the scope of this thesis to research more areas of cost and benefits was limited to considering the new technology obtain only as an alternative to the status quo. In addition, the analysis used estimates of some of the elements of costs, as inaccurate costs of new technologies are not available. However, the CBA developed in this thesis can be easily adjusted to incorporate more accurate data once it becomes available and therefore allow a certified contracting officer to pursue further the validity of an object/shape recognition technology option.

VI. CONCLUSION

A. INTRODUCTION

This chapter summarizes the project—a quest for answers to the problem that DLA DS at Camp Pendleton faces. Provide recommendations to the four areas of concerns. And, brief areas of uncertainty that would require further study.

The Lean Six Sigma study DLA DS conducted in 2008 resulted streamlining the item-disposal process by saving the time equivalent of 40% and concluded to conduct further study to exploit the operation process with technology. This thesis aimed to address the suggested new technology implementation option. Specifically, the thesis addressed the following research questions. Answering these questions was the key take away and culmination of the research.

1. Is there an object/shape recognition technology to support the feasibility of implementing it at DLA Disposition Services?
2. Secondary key questions to answer include the following: (1) What are the technology needs for DLA Disposition Services? (2) Is the technology mature enough for implementation? (3) Where will the technology and equipment be obtained? (4) How much will the equipment and technology cost and will it generate any tangible savings? (5) What is the payback period?

To answer the research questions this study utilized a retrospective mixed mode analysis of DLA DS's items disposal processing using data collected from Camp Pendleton, California, a technology readiness assessment (TRA) on object/shape recognition technology maturity level, and CBA to examine the feasibility to implement object/shape recognition technology. The technology readiness assessment and the CBA are consistent with the Circular A-94 (OMB, 1994), DOD Directive 5000.2 Interim (DOD, 2013a) and DOD TRA (Assistant Secretary of Defense for Research and Engineering [ASD(R&D)], 2011) guidance to calculate the object/shape recognition technology's benefits of reducing item research time. The study is retrospective in that it

included and assessed only a four-month period of data and, given that DLA DS is a non-profit organization, the researcher utilized a “market comparable approach” to calculate the benefits, costs, and return on investment. Although DLA DS does not have an overall comparable commercial market force to compare revenues, this approach allowed the researcher to use the market comparable labor as a form of estimating revenues.

B. PROJECT SUMMARY

This thesis’ objective was to understand the items disposal process and assess object/shape recognition technology to address the issue unlabeled items poses to DLA DS. However, the findings generated by the analysis of DLA DS’ items disposal processing show three other areas of concern that contribute to days’ worth of backlog items. The analysis suggests that the problem is not exactly the unlabeled items. Indeed, employees spend excess time conducting research on items that are not labeled or documented on the DD 1348 form. However, unlabeled items are less than 1% of accepted items and it does not fully contribute to days’ worth of backlog. Three other area of concern contributed to days’ worth of backlog. First, improperly filled DD 1348 provides for additional time spent conducting research in order to fill the DD 1348 form for further processing. Second, the receipt control numbers (RCNs) are not limited to the amount of items that can arrive in a pallet or tri-box. A RCN can have 1 or 50 items. This creates the potential to accept an average of 425 items in one day and DLA DS at Camp Pendleton capacity to process items is limited to 300 items with six-employee crew. Therefore, third, DLA DS at Camp Pendleton accepts more items than what it can process, which results in having an average of over 2,000 items in the backlog stowage area. The facility processes an average 300 items a day and had an average 47 RCN equaling to an average of 2,259 items or 7.5 days’ worth of backlog items stored for later processing.

This thesis examined the alternative of addressing the unlabeled items issues with the use of new object/shape recognition technology. The DLA DS technological requirement includes item recognition and disposal information feedback, and the ability to take pictures to use on DLA email system to communicate and upload the picture to

liquidations website. This thesis assessed the readiness level of existing object/shape recognition technology by analyzing three available such technologies:

First, technologies that are ready with DLA DS's specifications and operate in DLA DS similar environment have not been created, therefore none meet the required threshold of TRL 7 or above.

Cognex designed machines specific to customers' requirement and the company does not have a machine ready for DLA DS to operate straight out of the box, therefore Cognex TRL is 2. To implement Cognex's technology to DLA DS it will require further maturation of technology costing excess time and funding making Cognex technology less desirable to be adopted by DLA DS.

Imaginestics technology is an application for mobile devices and requires Internet to access the database for feedback. Lockheed Martin is utilizing Imaginestics' technology. The DOD funded Imaginestics' technology. Furthermore, Imaginestics has been approved for information assurance (IA) for another technology under the Navy and Office of the Secretary of Defense (OSD), therefore the company understand the DOD acquisition and IA approval process. However, Imaginestics object/shape recognition technology it ranks at TRL 5, but Imaginestics technology rates higher TRL amongst the three companies making it more desirable to pursue further maturation of Imaginestics technology. Investing in Imaginestics technology will cost less time and funding compared to the other two companies.

RMD's automated digital recognition technology (ADART) was artificial intelligence tool designed for the Marine Corps to capture and recognize mechanics' repair process for identification and feedback. However, the funding to further mature the technology was stalled and the machine is still in a prototype raking in TRL 2. To implement RMD's technology to DLA DS it will require further maturation of technology costing excess time and funding making RMD technology less desirable to be adopted by DLA DS.

The benefit from implementing object/shape recognition technology outweighs the cost to purchase it. The new technology will save money in labor costs for the

unlabeled items that are less than 1% of accepted items. The 10-year period of revenues provided by the technology recoups the \$150,000 initial investment in about seven years such that the internal rate of return of 15%, which is greater than the cost of capital estimated at 7%. The profitability index is \$0.43 to each one dollar invested, suggesting that DLA DS should execute the investment and pursue it for further maturation. However, implementing object/shape recognition technology does not fully contribute the reduction of days' worth of backlog. Therefore, the results from the queuing theory suggests that with nine employees the DLA DS at Camp Pendleton will keep up with demand by processing all received items and will progressively reduce the 7.5 days' worth of backlog.

One of the main conclusions resulted from this thesis effort is that researching items is not the only area of concern with regard to process inefficiency. Rather, this thesis identified three other areas of concern suggested by the data analysis and observation. Therefore, further recommendations were provided to take care of the other three problems.

C. RECOMMENDATIONS

Given the main findings identified by this thesis analysis, the recommendation to implement object/shape recognition is viable as far as generating a positive return to investment; however it only address less than 1% of items and not the 7.5 days' worth of backlog items for the DLA DS facility located in Camp Pendleton. Investing in Imaginestics' technology for further maturation will ease the disposal process for the 1% of unlabeled items.

Although this study recommends object/shape recognition to alleviate the 1% of accepted items, DLA DS must tackle the other three areas of concern with:

1. Making mandatory to fill the DD 1348 on DLA DS website, and
2. Limiting the amount of items on pallets to match the facility's processing capacity, and
3. Increasing the Camp Pendleton facility to nine employees, or

4. Adding a night shift such that the shift only process items without accepting or conducting mundane tasks, or
5. Once a month stop accepting items for disposal process for a full week in order to focus the effort to dispose the backlog items, or
6. Fill the gap with technology by implement full automation with optical sorting and data mining that included sensors, laser, object/shape recognition technology on conveyor belt system and data analytics to improve materiel's opportunity to be sold as commodity or liquidations and improve operational efficiency; which would be consistent with DLA Director's "Big Idea" and strategic technological goals to accomplish.

The technological innovation disrupts status quo by ensuring a plan of increased capacity for the long run and perhaps reduces some of the over \$60 million of labor cost that account for about 35% of DLA's budget.

D. RECOMMENDATION FOR FUTURE RESEARCH

Areas of uncertainty remain for future study. This study was not able to capture time spent in every step of the item disposal process, or observe whether the backlog is a cyclical trend due to retrograding units from deployments, cyclical due to time of the year, and value added from items that are scrapped rather than reaping on the opportunity to be sold and increase revenues. For example if the technology increases the opportunity to send more items for liquidations the opportunity would be in the benefit of increasing revenues to DLA. Additionally, the scope of the thesis narrowed the study the Camp Pendleton DLA DS facility, such that the results may not be indicative of all DLA DS.

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APPENDIX A. DISCLAIMER

The following disclaimer was adopted from the Department of Energy (DOE, 2012) because it is relevant to this study:

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference therein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The view and opinions of authors expressed therein do not necessarily state or reflect those of the United States Government or any agency thereof (p. iii).

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APPENDIX B. NORMALIZED DATA

Jul	through....	7/31/14	sorted by Region, Site & Date	Point in Time	Point in Time		Point in Time		Point in Time
ADD New DAILY Data to bottom (Paste Values), then Sort by Region, Site, Date				RCN Open Inventory	RCN AGE	RCN to Induct (RCNs)	Backlog Ending (Lines)	Receipts (Lines + Batches)	Backlog Ratio
Date	Region	Site ID	Site	Count	Oldest RCN	Days Avg	Backlog Count	Receipts	Ratio
7/1/14	West	RCCP	DLA DS PEND	30	12	6.6	1,082	466	232%
7/2/14	West	RCCP	DLA DS PEND	30	12	8.6	1,104	256	431%
7/3/14	West	RCCP	DLA DS PEND	30	12	8.6	1,703	375	454%
7/4/14	West	RCCP	DLA DS PEND	30	12			0	
7/5/14	West	RCCP	DLA DS PEND	30	12			0	
7/6/14	West	RCCP	DLA DS PEND	29	12		1,703	0	
7/7/14	West	RCCP	DLA DS PEND	31	13	9.9	2,320	231	1004%
7/8/14	West	RCCP	DLA DS PEND	31	14	10.0	2,417	357	677%
7/9/14	West	RCCP	DLA DS PEND	34	13	7.9	2,507	311	806%
7/10/14	West	RCCP	DLA DS PEND	37	14	3.6	2,530	298	849%
7/11/14	West	RCCP	DLA DS PEND	37	14	8.5	2,538	273	930%
7/12/14	West	RCCP	DLA DS PEND	37	14			0	
7/13/14	West	RCCP	DLA DS PEND	40	17		2,538	0	
7/14/14	West	RCCP	DLA DS PEND	44	15	14.3	2,353	351	670%
7/15/14	West	RCCP	DLA DS PEND	47	16	12.5	2,108	333	633%
7/16/14	West	RCCP	DLA DS PEND	51	17	13.5	2,055	303	678%
7/17/14	West	RCCP	DLA DS PEND	51	18	12.5	2,099	301	697%
7/18/14	West	RCCP	DLA DS PEND	51	18	10.5	2,544	232	1097%
7/19/14	West	RCCP	DLA DS PEND	51	18	16.1		401	0%
7/20/14	West	RCCP	DLA DS PEND	45	18		2,544	0	
7/21/14	West	RCCP	DLA DS PEND	47	19	15.4	2,446	157	1558%
7/22/14	West	RCCP	DLA DS PEND	54	16	13.4	2,431	213	1141%
7/23/14	West	RCCP	DLA DS PEND	59	17	6.4	2,410	107	2252%
7/24/14	West	RCCP	DLA DS PEND	51	18	4.9	2,273	230	988%
7/25/14	West	RCCP	DLA DS PEND	51	18	6.4	2,456	401	612%
7/26/14	West	RCCP	DLA DS PEND	51	18			0	
7/27/14	West	RCCP	DLA DS PEND	52	21		2,456	0	
7/28/14	West	RCCP	DLA DS PEND	47	22	10.2	2,313	508	455%
7/29/14	West	RCCP	DLA DS PEND	49	23	13.7	2,383	432	552%
7/30/14	West	RCCP	DLA DS PEND	53	24	6.9	2,601	520	500%
7/31/14	West	RCCP	DLA DS PEND	62	25	13.7	3,072	140	2194%

Figure 29. Normalized Data Treated with Excel's Default Setting "Show empty data as zero"

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APPENDIX C. NPV SENSITIVITY ANALYSIS TABLE

Sensitivity Analysis - NPV												
Discount Rate 'r'												
Growth 'g'		5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
	2%	\$ 78,844	\$ 67,792	\$ 57,520	\$ 47,963	\$ 39,058	\$ 30,752	\$ 22,995	\$ 15,743	\$ 8,954	\$ 2,594	\$ 3,373
	3%	\$ 88,652	\$ 76,954	\$ 66,088	\$ 55,983	\$ 46,574	\$ 37,802	\$ 29,616	\$ 21,966	\$ 14,810	\$ 8,108	\$ 1,825
	4%	\$ 98,971	\$ 86,588	\$ 75,094	\$ 64,409	\$ 54,467	\$ 45,203	\$ 36,562	\$ 28,493	\$ 20,948	\$ 13,887	\$ 7,270
	5%	\$ 109,828	\$ 96,721	\$ 84,560	\$ 73,264	\$ 62,757	\$ 52,973	\$ 43,852	\$ 35,338	\$ 27,383	\$ 19,941	\$ 12,972
	6%	\$ 121,252	\$ 107,377	\$ 94,512	\$ 82,567	\$ 71,463	\$ 61,129	\$ 51,500	\$ 42,518	\$ 34,129	\$ 26,286	\$ 18,945
	7%	\$ 133,269	\$ 118,583	\$ 104,972	\$ 92,341	\$ 80,606	\$ 69,691	\$ 59,526	\$ 50,048	\$ 41,201	\$ 32,935	\$ 25,202
	8%	\$ 145,912	\$ 130,367	\$ 115,967	\$ 102,611	\$ 90,209	\$ 78,679	\$ 67,947	\$ 57,946	\$ 48,616	\$ 39,902	\$ 31,755
	9%	\$ 159,211	\$ 142,757	\$ 127,523	\$ 113,401	\$ 100,293	\$ 88,114	\$ 76,783	\$ 66,230	\$ 56,390	\$ 47,204	\$ 38,620
	10%	\$ 173,200	\$ 155,785	\$ 139,668	\$ 124,736	\$ 110,884	\$ 98,018	\$ 86,055	\$ 74,919	\$ 64,540	\$ 54,856	\$ 45,812
	11%	\$ 187,914	\$ 169,482	\$ 152,433	\$ 136,644	\$ 122,004	\$ 108,414	\$ 95,784	\$ 84,032	\$ 73,084	\$ 62,876	\$ 53,345
	12%	\$ 203,388	\$ 183,881	\$ 165,847	\$ 149,153	\$ 133,682	\$ 119,326	\$ 105,991	\$ 93,589	\$ 82,042	\$ 71,280	\$ 61,237

Figure 30. A Sensitivity Analysis of Wages between Social Discount Rate (Growth “g”) and Discount Rate “r”

Figure 30 illustrates the sensitivity analysis that supports the CBA by changing the wages social discount as a form of revenues from pay raise or cut between the time value money discount rate for assumptions in order to understand risk factors in investing that object/shape recognition technology inherit.

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